GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. G-35-663 DATE 7/28/82

Project Director: R. G. Roper School/Lab Geo. Sci.

Sponsor: National Science Foundation

Type Agreement: Grant No. ATM-8207097

Award Period: From 7/1/82 To 12/31/83 (Performance) 3/31/84 (Reports)

Sponsor Amount: $50,400 Contracted through:

Cost Sharing: $2,486 (G-35-368) GTRI/~~GIT~~

Title: Continuous Operation of the Georgia Tech Meteor Wind Radar, 1982-83

ADMINISTRATIVE DATA

OCA Contact Linda H. Bowman

1) Sponsor Technical Contact:

Vincent B. Wickwar
Nadtional Science Foundation
Washington, D. C. 20550
202-357-7619

2) Sponsor Admin/Contractual Matters:

Mary Frances O'Connell
National Science Foundation
Washington, D. C. 20550
202-357-9602

Defense Priority Rating: n/a

Security Classification: n/a

RESTRICTIONS

See Attached NSF Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT

COMMENTS:

Continuation of G-35-604

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Other ______

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 10/10/84

Project No. G-35-663 School/~~Lab~~ Geo. Sci.

Includes Subproject No.(s) N/A

Project Director(s) Dr. R G. Roper GTRI / GIT

Sponsor National Science Foundation.

Title "Continuous Operation of the Georgia Tech Meteor Wind Radar, 1982-83"

Effective Completion Date: 12/31/83 (Performance) 3/31/84 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [x] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [x] Final Report of Inventions if positive
- [x] Govt. Property Inventory & Related Certificate if positive
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No.

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G-35-613

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT

NSF FORM 98A

PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING

PART I–PROJECT IDENTIFICATION INFORMATION

1. Institution and Address	2. NSF Program	3. NSF Award Number
Georgia Institute of Technology Atlanta, GA 30332	AERONOMY	ATM 8207097
	4. Award Period From 7/1/82 To 12/31/83	5. Cumulative Award Amount $50,400

6. Project Title

Continuous Operation of the Georgia Tech Meteor Wind Radar, 1982-83

PART II–SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

With the exception of short intervals of downtime required for system maintenance, continuous operation of the Georgia Tech Radio Meteor Facility was achieved for the period July 1, 1982, through July 31, 1983, when a catastrophic failure of the transmitter, followed later by failure of the data tape recorder at the fieldsite, suspended operation until December 21, 1983.

Some results from this grant period, together with observations made previously under NSF sponsorship, were presented at the following international meetings - The Workshop on MST Radars, Urbana, Illinois, May, 1983; The International Symposium on Ground-Based Studies of the Middle Atmosphere, Schwerin, GDR, May, 1983, and the Workshop on Tides in the Middle Atmosphere, IUGG Assembly, Hamburg, FRG, August, 1983.

The most interesting aspect of these results is that they confirm previously postulated results, in that not only do winter polar stratospheric warmings affect mesopause level circulation at latitudes as low as Atlanta (34°N), but that the lower thermospheric circulation over Atlanta is often characteristic of the equatorial regime.

PART III–TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

1. ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM: Check (✓)	Approx. Date
a. Abstracts of Theses	X				
b. Publication Citations	X				
c. Data on Scientific Collaborators		X			
d. Information on Inventions	X				
e. Technical Description of Project and Results				X	5/31/84
f. Other *(specify)* Paper by Ahmed and Roper		X			

2. Principal Investigator/Project Director Name *(Typed)*	3. Principal Investigator/Project Director Signature	4. Date
R. G. Roper		4/5/84

NSF Form 98A (5-78) Supersedes All Previous Editions

Form Approved OMB No. 99R0013

FINAL TECHNICAL REPORT
PROJECT NO. G-35-663

RADIO METEOR WINDS MEASURED OVER ATLANTA (34° N, 84° W), JULY, 1980 – DECEMBER, 1983

Prepared by

R. G. Roper

Prepared for

ATMOSPHERIC RESEARCH SECTION
NATIONAL SCIENCE FOUNDATION

Under Contract No. ATM82-07097

Period Covering July 1, 1982 – December 31, 1983

SEPTEMBER 1984

GEORGIA INSTITUTE OF TECHNOLOGY
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
SCHOOL OF GEOPHYSICAL SCIENCES
ATLANTA, GEORGIA 30332

1984

Radio Meteor Winds Measured Over Atlanta (34°N, 84°W)
July, 1980 - December, 1983

R. G. Roper
Professor
Georgia Institute of Technology
School of Geophysical Sciences
Atlanta, GA 30332

Final Technical Report on research supported by the Atmospheric Research Section of the National Science Foundation, under Grant No. ATM82-07097

Georgia Tech Project G-35-663

Contract Period July 1, 1982 - December 31, 1983

September, 1984

C O N T E N T S

Radio Meteor Winds Measured Over Atlanta (34°N, 84°W)
July, 1980 - December, 1983

CHAPTER I

Introduction

Since August, 1974, the Georgia Tech Radio Meteor Wind Facility has been in routine operation, measuring winds between 80 and 100 kilometers altitude over Atlanta, Georgia, USA.

A continuous wave technique is employed, with a transmitter located on the Georgia Tech campus, and a receiving site at Technology Park/Atlanta, 27 km northeast of the campus. A description of the equipment has been published by Roper (1975a), and a detailed systems manual is available (Roper, 1975b).

Wind results for the period August 1974 through December 1977 have been published in a previous contract report (Roper, 1978). Further analysis of these results appear in Salby and Roper (1980), Dolas and Roper (1981), and Ahmed and Roper (1982).

Results

The tabulations presented in this report are the result of matching the data against the model developed by Groves (1959). The model assumes cubic variations with height of the north-south and east-west components of the prevailing wind and the diurnal and semidiurnal wind components. The vertical wind is considered to be constant with height, but having dirunal and semidiurnal periodicities in time. Vertical winds are not tabulated; their significance is being further investigated, but, in general, their amplitudes are less than 10% of the horizontal components.

Wind amplitudes are in meters sec^{-1}; wind directions are positive for a wind blowing toward the east (a westerly) and toward the north (a southerly). Phases of the diurnal and semidiurnal components are times of maximum amplitude relative to local mean solar midnight (local mean solar time for Atlanta is Coordinated Universal Time minus 5 hours and 37 minutes).

In the tables, HEIGHT is the altitude in kilometers; MEAN is the prevailing wind, the constant coefficient of the Fourier series fitted to the data over the interval of measurement; and ER is the error to be associated with each component, be it amplitude (meters sec^{-1}) or phase (hours), and is one standard deviation.

While every effort is made to operate the facility continuously, interference from aircraft reflections and inadequate manpower have proved to be a problem. Significant results have been achieved for monthly means, and occasionally by averaging from 7 days to 2 weeks data - averaging intervals appear as headers to the wind printout, and there are some gaps.

Because of the F region backscatter evident at the 32.5 MHz transmitting frequency during sunspot maximum, there is contamination of the data by backscatter "echoes" which commences during the winter of 1980-81, and is still evident in early 1982 (the present radar is able to discriminate against interference on the basis of range only. Thus backscatter echoes that fold back into the meteor region will be recorded as meteor echoes).

The use of better echo selection criteria, and averaging over a longer interval (in particular, the production of monthly means) has resulted in significant modification of the results for July, 1980 through May, 1982 as published in "Radio Meteor Winds Measured Over Atlanta (34°N, 84°W), January 1978 - May, 1982", the Final Technical Report on Project No. E-16-622 and G-35-604 published in November, 1982.

The Georgia Tech Radio Meteor Wind Facility was initially funded by the Georgia Institute of Technology. Since 1971, support has been provided by the Atmospheric Research Section of the Naitonal Science Foundation, first under Grant No. GA26626 (1971-1975), then under Grant No. ATM75-14414, Grant No. ATM78-11741, and Grant No. ATM82-07097.

References

Ahmed, M.T. and R.G. Roper, "The Diurnal and Semidiurnal Oscillations in Meteor Winds Over Atlanta," J. Atmos. Terrest. Physics, 45, 181-192, 1983.

Dolas, P.M. and R.G. Roper, "Prevailing Wind in the Meteor Zone Over Atlanta, and its Association with Mid-winter Stratospheric Warming," J. Atmos. Sci., 38, 182-188, 1981.

Groves, G.V., "A Theory for Determining Upper Atmosphere Winds from Radio Observations on Meteor Trails," J. Atmos. Terrest. Phys., 16, 344-356, 1959.

Roper, R.G., "The Measurement of Meteor Winds Over Atlanta, (34°N, 84°W)," Radio Sci., 10, 363-369, 1975a.

Roper, R.G., "The Georgia Tech Radio Meteor Wind Facility," Final Technical Reoprt on Research supported by the Atmospheric Science Section of the National Science Foundation under Grant No. GA26626, May, 1975b.

Roper, R.G., "Radio Meteor Winds Measured Over Atlanta (34°N, 84°W), August, 1974 - December 1977," Final Technical Report, NSF Grant No. ATM75-14414, July, 1978.

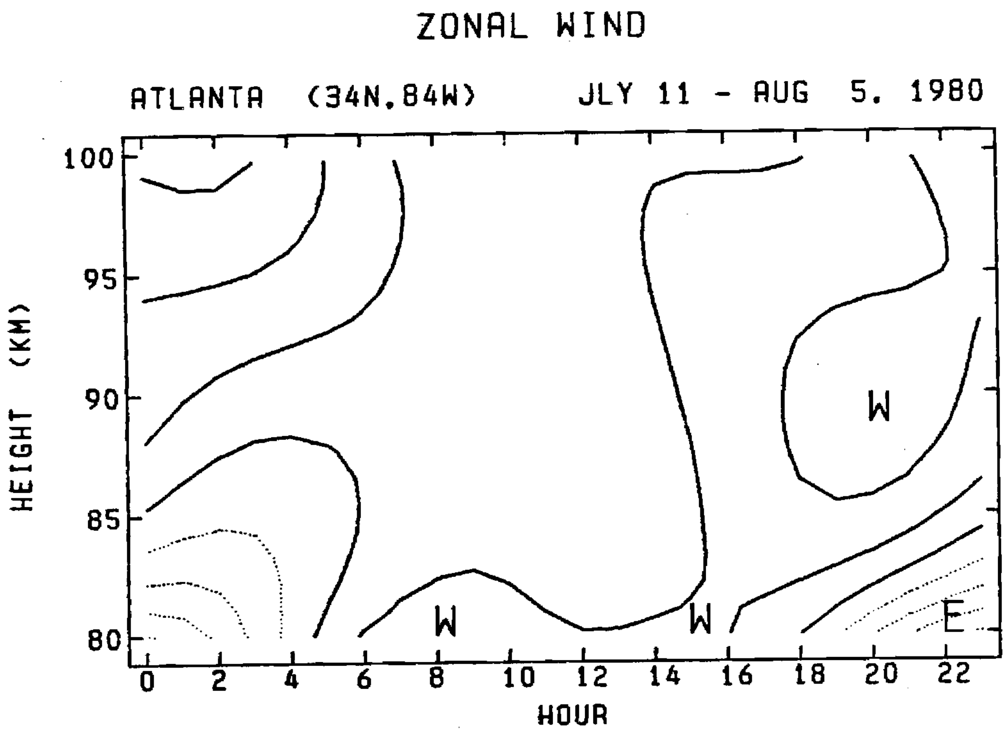
Salby, Murry L., and R.G. Roper, "Long Period Oscillations in the Meteor Region," J. Atmos. Sci., 37, 237-244, 1980.

CHAPTER II

The following are tables and plots of the wind values determined by the Groves technique for the intervals indicated.

The contour plot computer program does not as yet label contours. The zero contour is the first dashed contour adjacent to a full contour. Full contours represent positive wind values (westerlies or southerlies, as appropriate) and dashed contours (with the exception of the zero contour) negative wind values (easterlies or northerlies). Absolute profiles at any time of day can be computed from the tables.

One should note that the presence of easterlies in both summer and winter is much more characteristic of the equatorial mesopause circulation than that measured at higher midlatitudes.



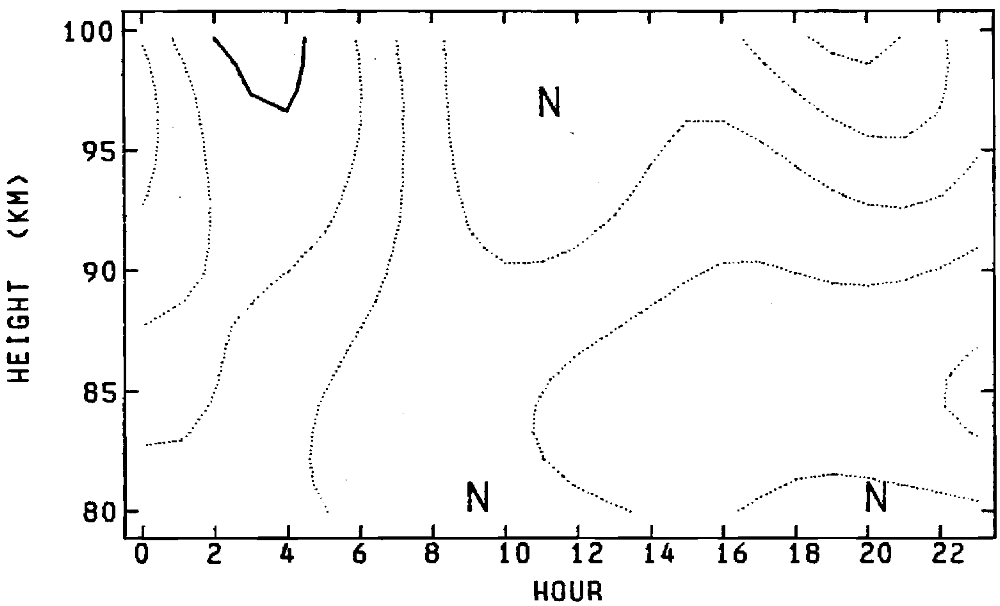
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

JLY 11 - AUG 5 1980

HEIGHT	MEAN	ERROR	24 HOUR AMP	ERROR	PHI	ERROR	12 HOUR AMP	ERROR	PHI	ERROR
100	26.	7.	15.	10.	1.	2.	6.	9.	1.	3.
96	25.	6.	8.	9.	24.	4.	3.	8.	3.	6.
92	23.	5.	9.	7.	21.	3.	2.	7.	7.	8.
88	19.	5.	10.	7.	19.	3.	5.	7.	8.	3.
84	13.	6.	11.	8.	14.	3.	7.	8.	7.	2.
80	2.	9.	35.	13.	11.	1.	14.	11.	5.	1.

MERIDIONAL WIND

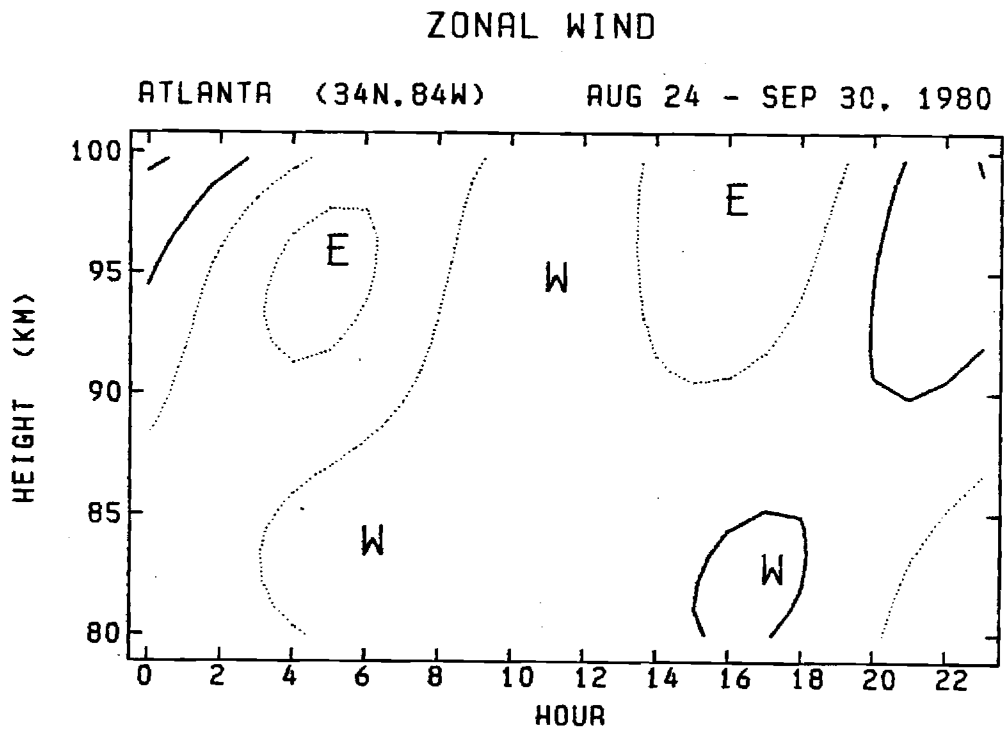
ATLANTA (34N,84W)   JLY 11 - AUG 5, 1980



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JLY 11 - AUG 5 1980

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-18.	6.	22.	8.	5.	2.	15.	8.	2.	1.
96	-17.	6.	15.	8.	4.	2.	12.	8.	4.	1.
92	-12.	5.	9.	6.	2.	3.	8.	6.	4.	2.
88	-7.	5.	6.	7.	23.	4.	3.	7.	2.	4.
84	-7.	5.	5.	8.	21.	5.	4.	7.	1.	3.
80	-15.	6.	3.	9.	6.	13.	6.	9.	4.	3.



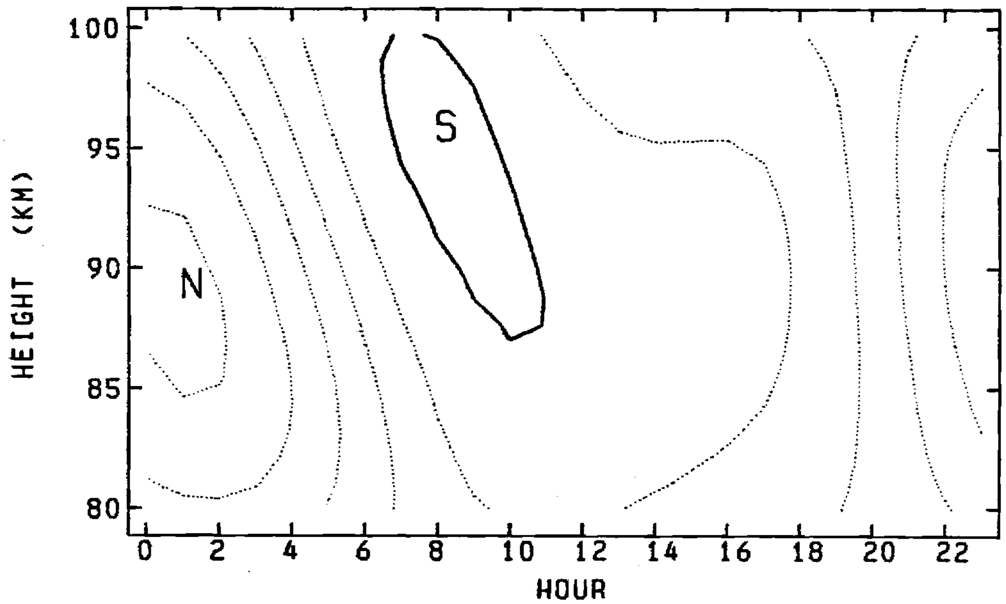
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

AUG 24 - SEP 30 1980

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	5.	8.	11.	12.	1.	3.	9.	9.	0.	2.
96	1.	7.	6.	9.	21.	6.	11.	8.	11.	1.
92	1.	6.	5.	7.	18.	6.	8.	7.	10.	2.
88	3.	6.	4.	9.	16.	7.	3.	8.	8.	4.
84	3.	7.	5.	10.	14.	7.	5.	8.	6.	3.
80	0.	8.	8.	13.	14.	5.	4.	10.	5.	5.

MERIDIONAL WIND

ATLANTA (34N,84W) AUG 24 - SEP 30, 1980



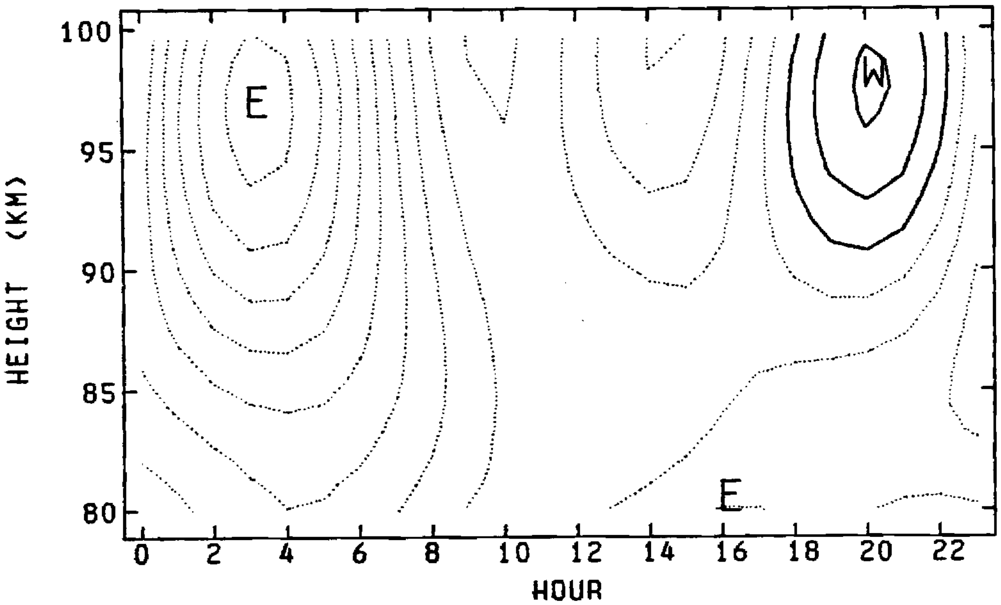
NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

AUG 24 - SEP 30 1980

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-7.	7.	12.	8.	8.	3.	5.	8.	6.	3.
96	-7.	6.	18.	8.	11.	2.	9.	7.	6.	2.
92	-9.	5.	23.	7.	12.	1.	9.	6.	7.	1.
88	-10.	5.	25.	7.	13.	1.	7.	6.	7.	2.
84	-12.	5.	22.	8.	13.	1.	5.	7.	8.	2.
80	-11.	6.	11.	8.	13.	3.	3.	8.	9.	5.

ZONAL WIND

ATLANTA (34N,84W) OCT 1 - OCT 14, 1980



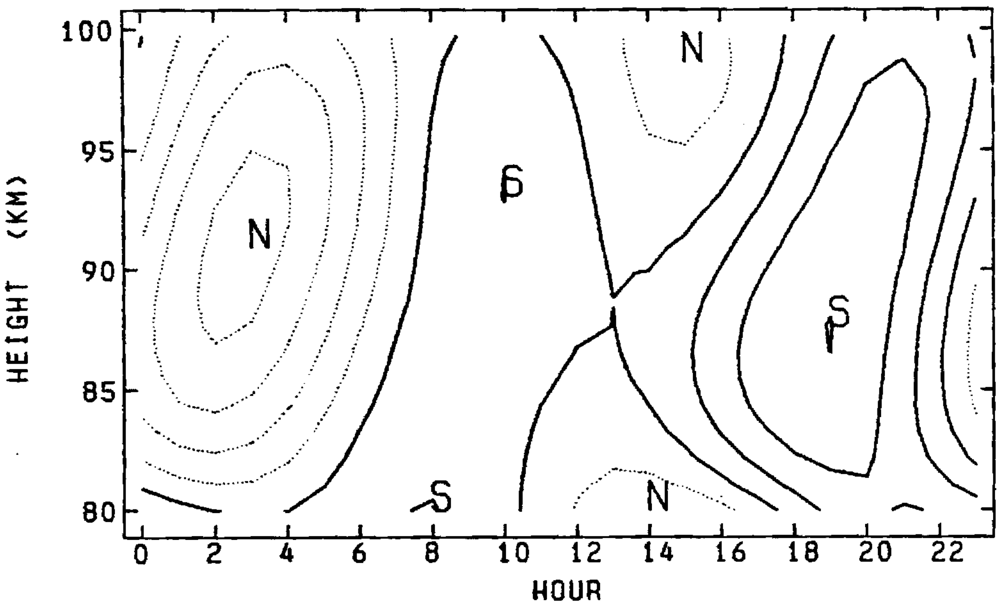
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

OCT 1 - OCT 14 1980

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-21.	16.	25.	20.	17.	3.	32.	16.	9.	1.
96	-22.	13.	33.	17.	17.	2.	34.	14.	9.	1.
92	-22.	11.	31.	14.	16.	2.	24.	12.	9.	1.
88	-21.	11.	24.	16.	15.	2.	11.	12.	10.	2.
84	-19.	13.	14.	18.	15.	4.	7.	14.	11.	4.
80	-15.	18.	3.	20.	20.	29.	13.	18.	10.	3.

MERIDIONAL WIND

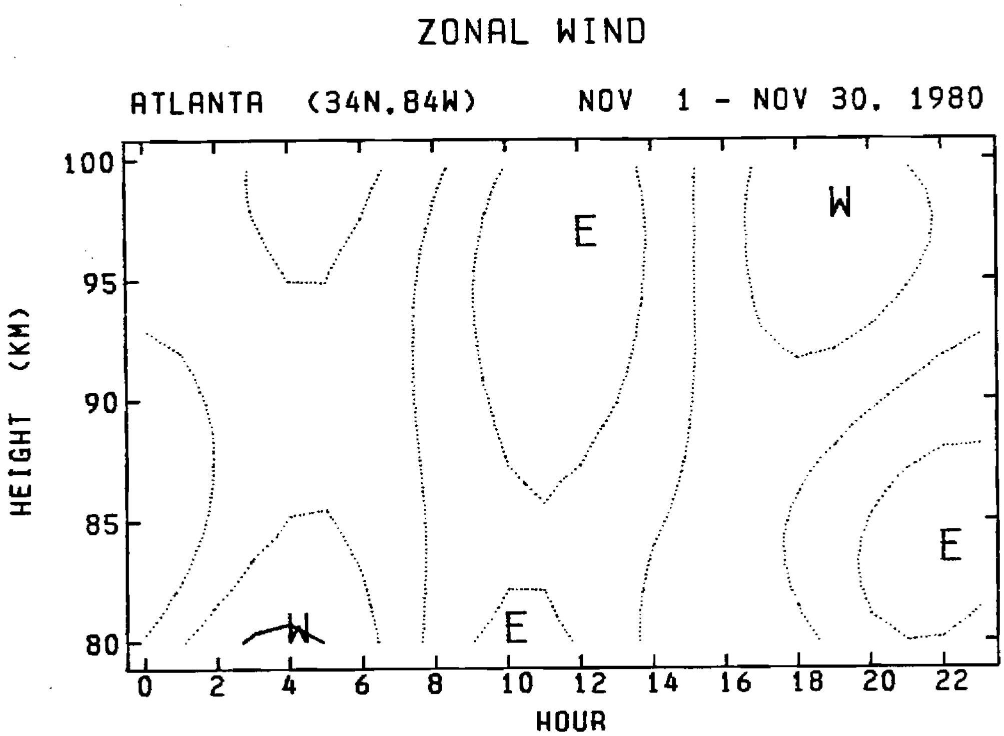
ATLANTA (34N,84W) OCT 1 - OCT 14, 1980



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

OCT 1 - OCT 14 1980

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	6.	12.	8.	14.	19.	9.	10.	12.	9.	2.
96	5.	12.	15.	14.	17.	5.	20.	12.	9.	1.
92	6.	9.	22.	12.	16.	2.	19.	10.	9.	1.
88	8.	9.	24.	14.	16.	2.	18.	11.	8.	1.
84	10.	13.	13.	18.	16.	4.	15.	13.	7.	2.
80	13.	19.	20.	29.	1.	4.	14.	16.	9.	3.



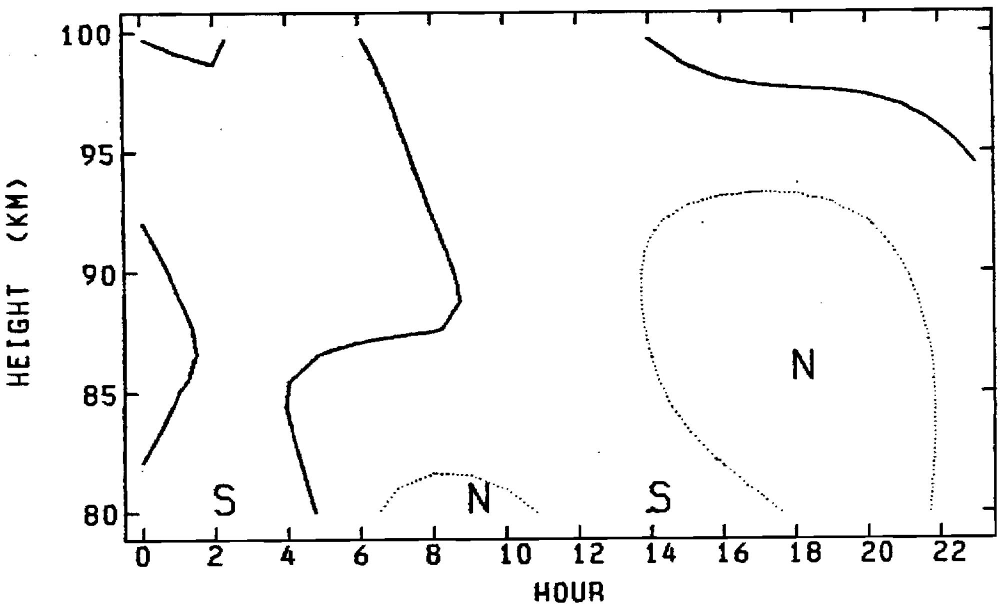
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

NOV 1 - NOV 30 1980

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-6.	5.	7.	8.	1.	3.	10.	7.	6.	1.
96	-7.	5.	12.	7.	23.	2.	10.	6.	6.	1.
92	-10.	4.	7.	6.	23.	3.	9.	5.	5.	1.
88	-13.	4.	2.	6.	4.	9.	9.	5.	5.	1.
84	-12.	5.	6.	6.	6.	5.	11.	6.	4.	1.
80	-6.	6.	10.	9.	2.	3.	15.	8.	4.	1.

MERIDIONAL WIND

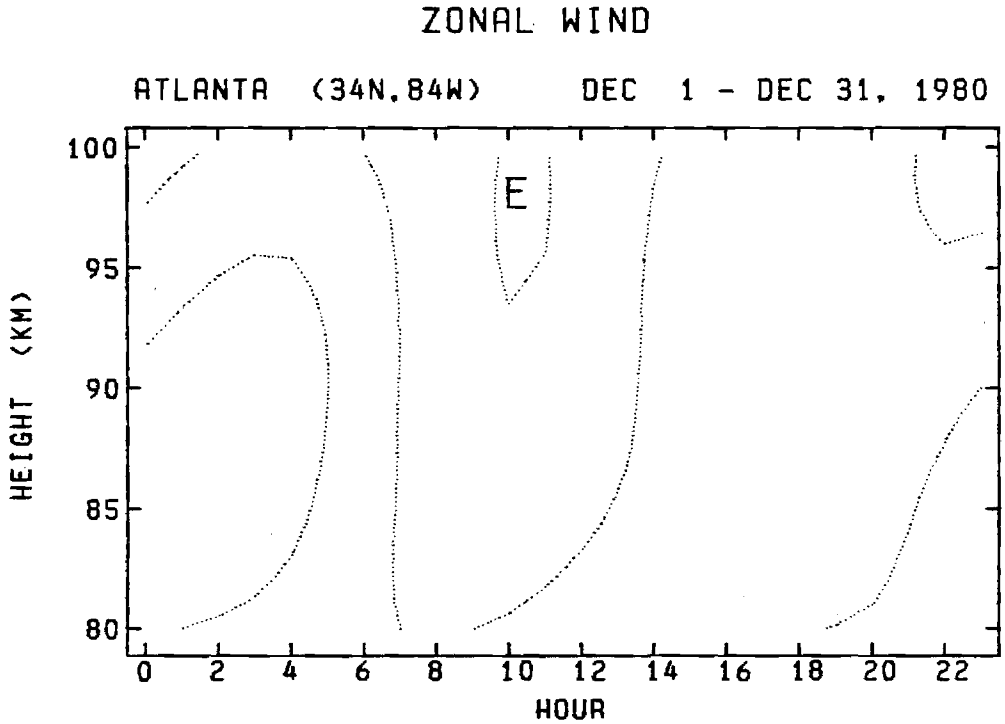
ATLANTA (34N.84W) NOV 1 - NOV 30, 1980



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

NOV 1 - NOV 30 1980

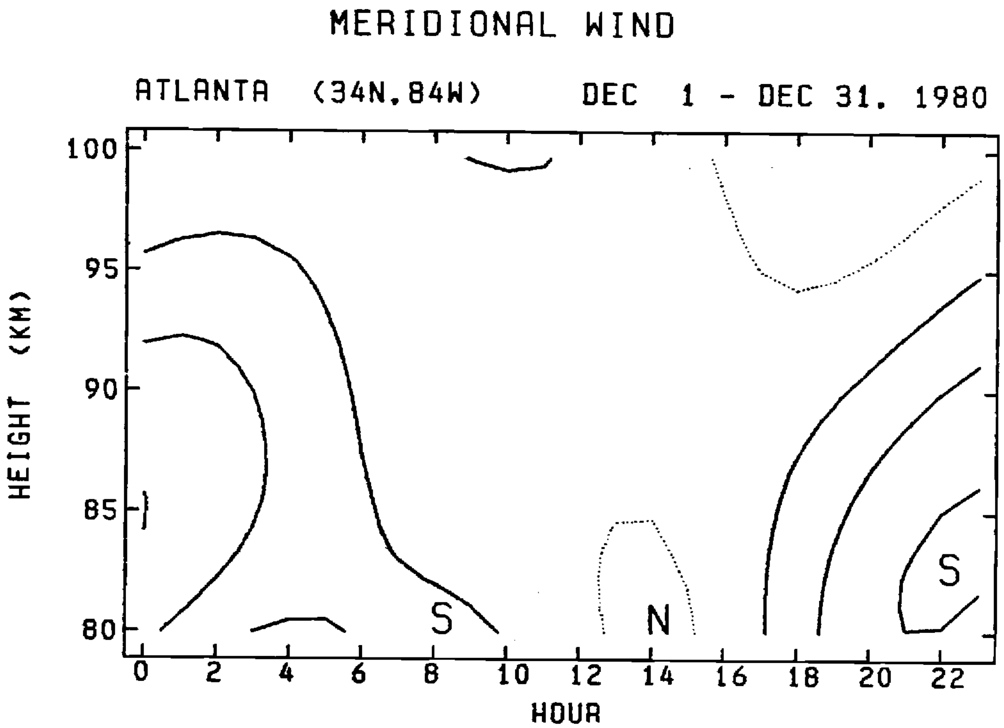
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	14.	4.	8.	6.	22.	3.	3.	6.	2.	4.
96	10.	4.	7.	6.	2.	3.	3.	6.	3.	4.
92	6.	3.	9.	5.	4.	2.	1.	5.	2.	8.
88	4.	4.	10.	5.	6.	2.	3.	5.	12.	4.
84	3.	4.	7.	6.	5.	3.	5.	6.	1.	2.
80	6.	5.	6.	7.	24.	5.	13.	7.	2.	1.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

DEC 1 - DEC 31 1980

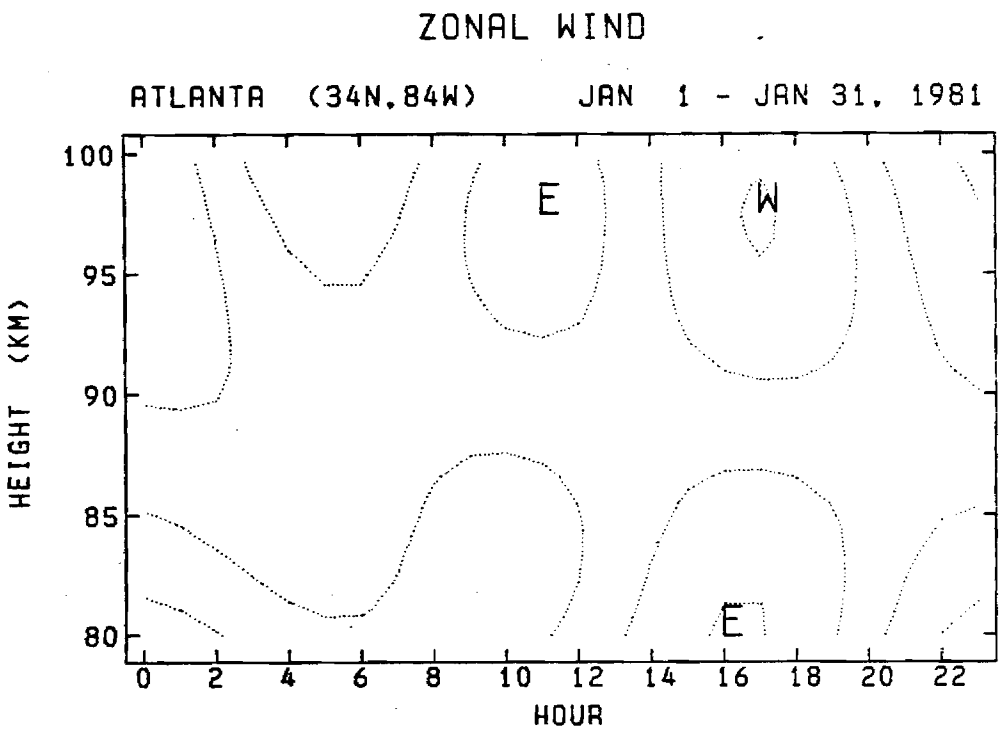
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-22.	5.	5.	6.	20.	6.	5.	6.	5.	3.
96	-19.	4.	5.	6.	22.	5.	7.	6.	4.	2.
92	-16.	4.	8.	5.	24.	2.	6.	5.	4.	1.
88	-15.	4.	10.	5.	0.	2.	5.	5.	3.	2.
84	-14.	4.	9.	6.	23.	2.	3.	6.	2.	3.
80	-14.	5.	6.	6.	19.	5.	0.	6.	8.	32.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

DEC 1 - DEC 31 1980

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	2.	4.	8.	5.	9.	3.	2.	5.	11.	7.
96	5.	4.	5.	5.	6.	5.	3.	5.	1.	3.
92	9.	3.	8.	5.	1.	2.	4.	4.	1.	2.
88	12.	3.	13.	5.	0.	1.	3.	4.	12.	3.
84	14.	4.	14.	6.	24.	1.	5.	5.	10.	2.
80	12.	5.	8.	6.	23.	3.	10.	6.	9.	1.



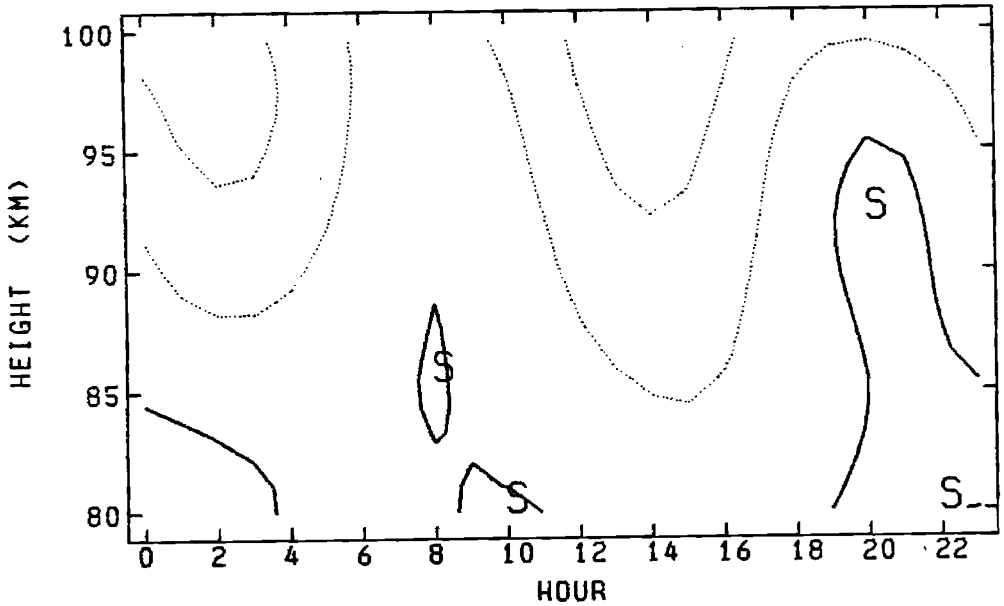
EAST-WEST WIND COMPONENTS, ATLANTA (34N,34W)

JAN 1 - JAN 31 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-14.	6.	5.	7.	9.	6.	13.	7.	5.	1.
96	-15.	5.	4.	8.	15.	6.	12.	6.	5.	1.
92	-16.	4.	4.	6.	15.	5.	6.	5.	6.	2.
88	-15.	4.	2.	6.	10.	10.	3.	5.	10.	4.
84	-13.	5.	7.	6.	5.	4.	8.	6.	11.	1.
80	-10.	6.	15.	9.	2.	2.	8.	7.	11.	2.

MERIDIONAL WIND

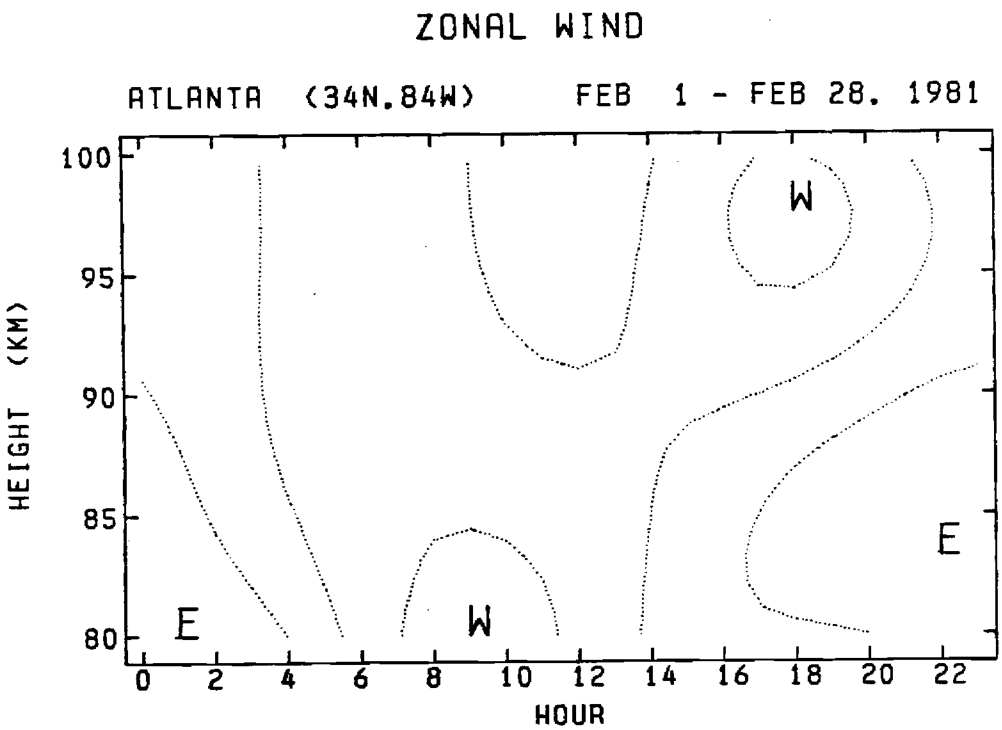
ATLANTA (34N,84W) JAN 1 - JAN 31, 1981



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JAN 1 - JAN 31 1981

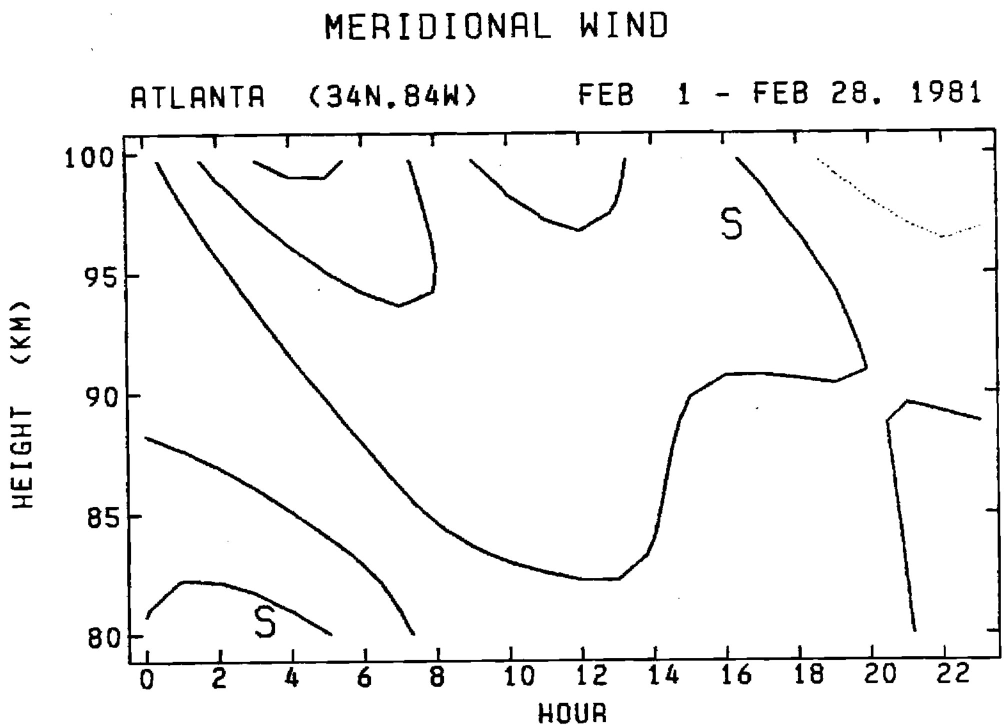
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-8.	5.	5.	6.	7.	6.	7.	6.	7.	2.
96	-3.	5.	1.	6.	22.	27.	11.	6.	8.	1.
92	1.	4.	2.	5.	23.	11.	10.	5.	8.	1.
88	5.	4.	2.	6.	1.	7.	6.	5.	8.	2.
84	8.	4.	4.	6.	2.	5.	3.	5.	9.	3.
80	11.	5.	6.	8.	24.	4.	6.	6.	11.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

FEB 1 - FEB 28 1981

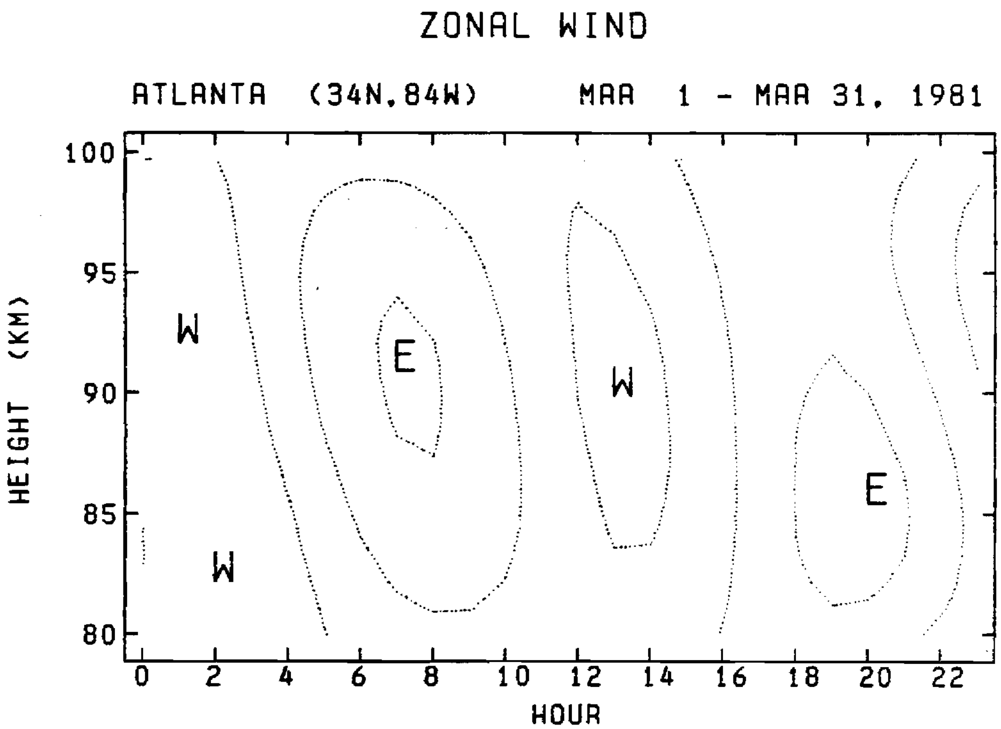
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-10.	6.	2.	9.	12.	16.	8.	7.	6.	2.
96	-8.	6.	4.	8.	17.	8.	8.	7.	6.	2.
92	-10.	5.	4.	6.	11.	6.	5.	6.	6.	2.
88	-13.	5.	11.	6.	9.	3.	2.	6.	5.	5.
84	-15.	5.	16.	7.	9.	2.	1.	7.	6.	12.
80	-13.	6.	14.	9.	11.	3.	9.	9.	8.	2.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

FEB 1 - FEB 28 1981

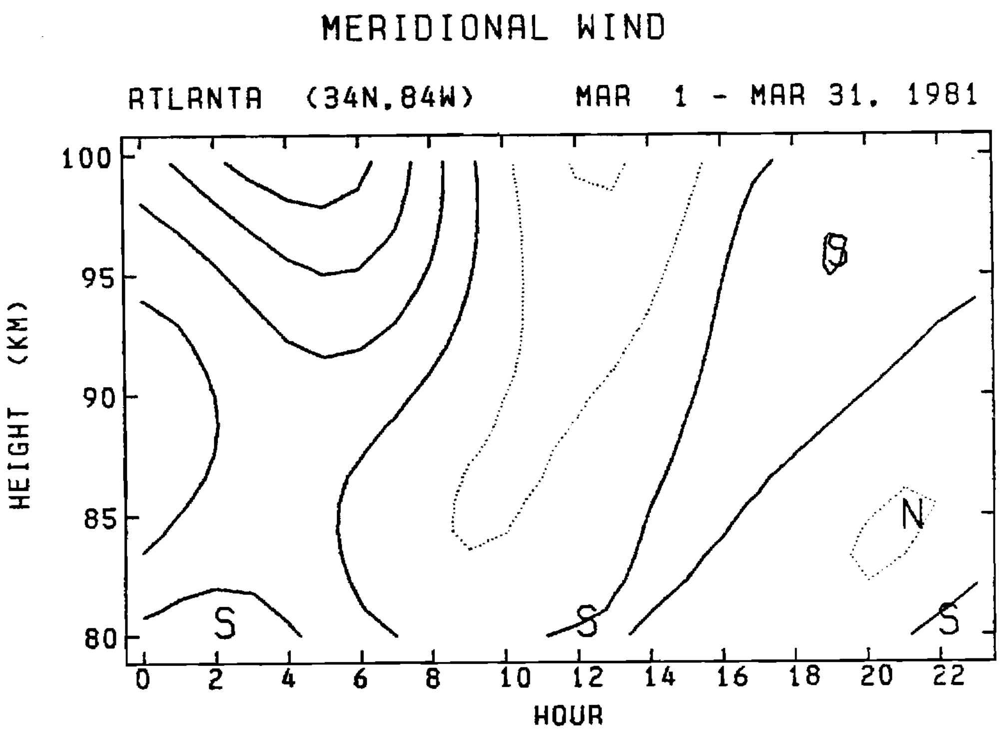
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	11.	5.	15.	7.	6.	2.	13.	7.	3.	1.
96	12.	5.	8.	6.	8.	4.	6.	6.	5.	2.
92	11.	4.	5.	5.	10.	4.	3.	5.	7.	4.
88	11.	4.	2.	6.	10.	10.	3.	6.	11.	3.
84	11.	5.	4.	8.	3.	6.	4.	6.	0.	3.
80	13.	6.	11.	9.	2.	3.	7.	8.	3.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

MAR 1 - MAR31 1981

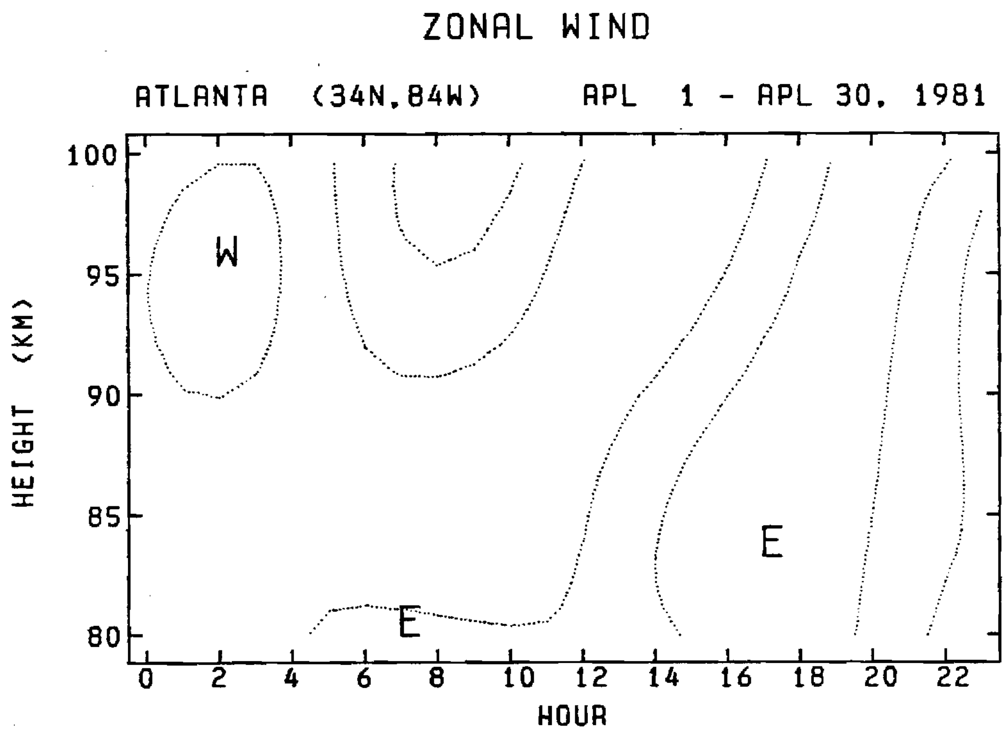
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-7.	7.	9.	9.	6.	5.	4.	8.	0.	4.
96	-7.	6.	3.	9.	1.	10.	10.	7.	0.	1.
92	-8.	5.	3.	7.	24.	10.	13.	6.	1.	1.
88	-9.	5.	3.	7.	4.	9.	13.	6.	2.	1.
84	-8.	6.	6.	7.	5.	5.	11.	7.	2.	1.
80	-4.	6.	8.	9.	4.	4.	5.	9.	1.	3.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

MAR 1 - MAR31 1981

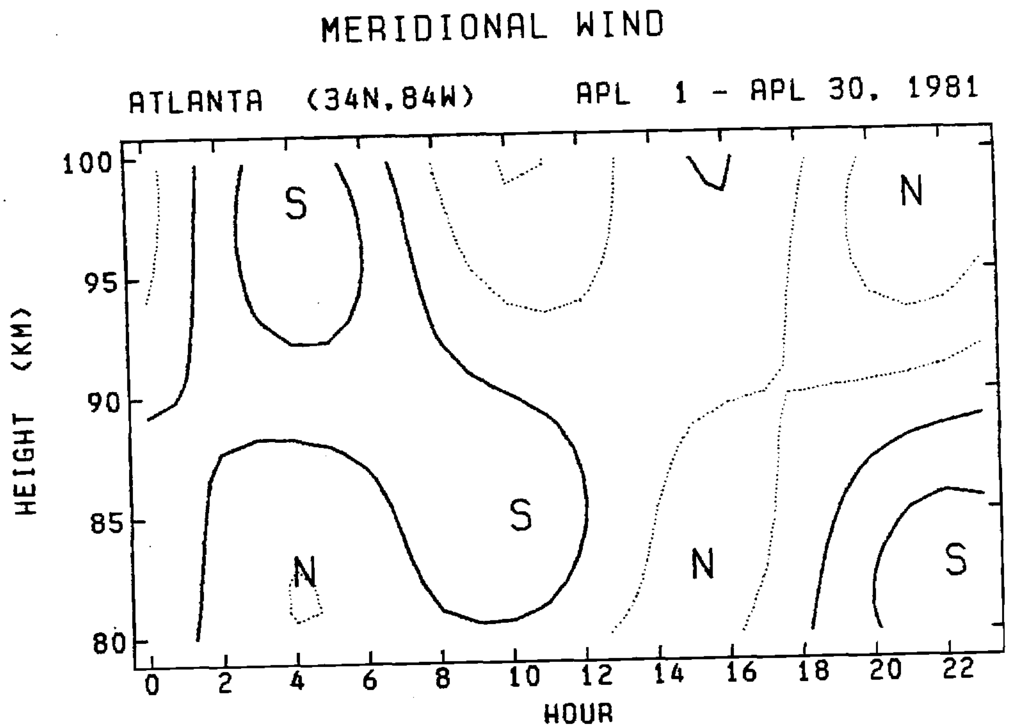
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	18.	6.	27.	10.	3.	1.	11.	7.	5.	1.
96	15.	5.	14.	8.	2.	2.	11.	6.	6.	1.
92	10.	4.	5.	7.	1.	4.	9.	5.	6.	1.
88	6.	4.	1.	6.	0.	18.	7.	5.	4.	2.
84	7.	5.	3.	7.	3.	7.	7.	6.	3.	2.
80	15.	5.	12.	8.	3.	2.	6.	7.	0.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

APL 1 - APL30 1981

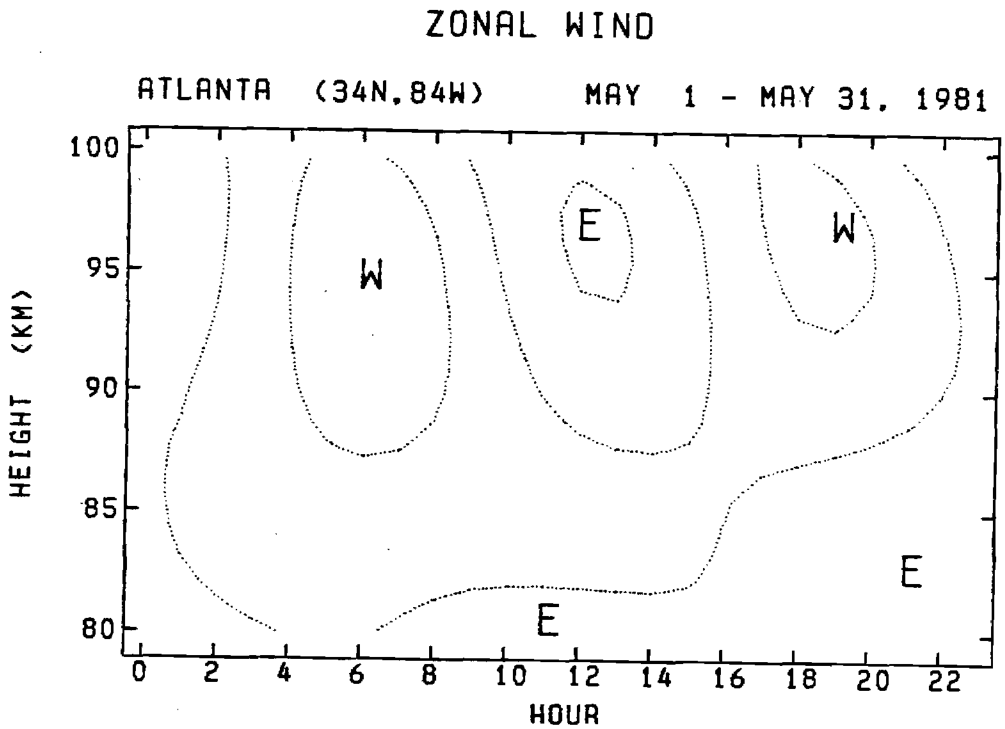
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-14.	5.	1.	8.	13.	46.	11.	7.	3.	1.
96	-10.	5.	3.	7.	3.	7.	12.	6.	2.	1.
92	-10.	4.	7.	6.	5.	3.	8.	5.	1.	1.
88	-11.	4.	10.	6.	6.	2.	5.	5.	12.	2.
84	-12.	5.	10.	6.	5.	2.	5.	6.	11.	2.
80	-13.	6.	8.	8.	2.	3.	8.	7.	0.	2.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

APL 1 - APL30 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	2.	5.	5.	7.	5.	4.	14.	6.	4.	1.
96	3.	4.	10.	6.	6.	2.	15.	5.	4.	1.
92	6.	3.	9.	5.	6.	2.	6.	4.	4.	2.
88	9.	3.	5.	5.	4.	3.	5.	5.	10.	2.
84	10.	4.	5.	6.	24.	4.	11.	5.	10.	1.
80	6.	5.	9.	7.	22.	3.	5.	7.	9.	2.



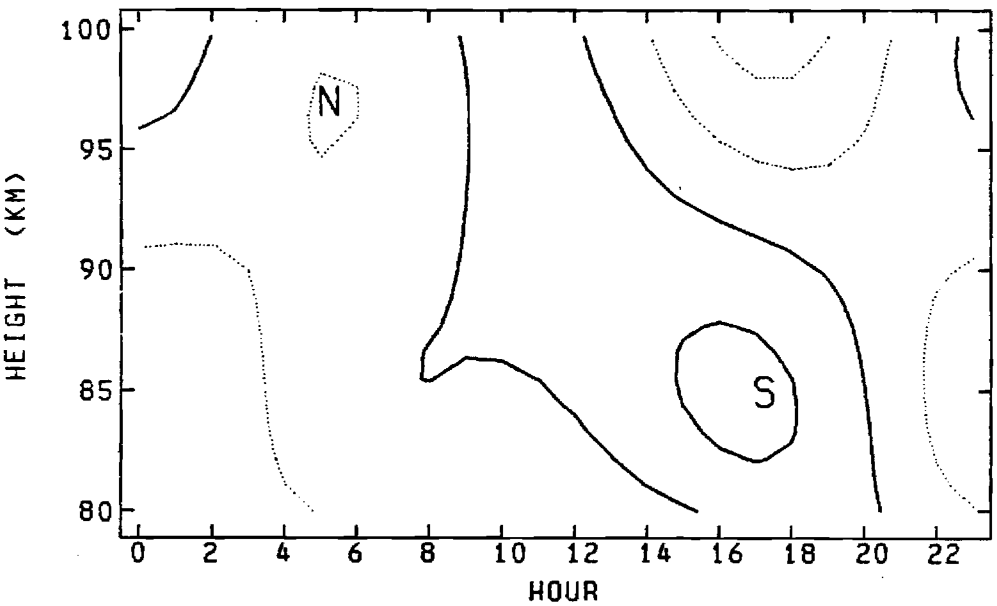
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

MAY 1 - MAY 31 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-9.	6.	2.	10.	12.	20.	9.	8.	5.	2.
96	-7.	6.	3.	9.	2.	8.	12.	8.	6.	1.
92	-6.	5.	4.	7.	4.	6.	9.	6.	7.	1.
88	-7.	5.	5.	6.	7.	6.	3.	6.	6.	4.
84	-10.	6.	5.	7.	8.	8.	2.	7.	3.	7.
80	-14.	7.	2.	11.	23.	18.	4.	9.	6.	4.

MERIDIONAL WIND

ATLANTA (34N,84W) MAY 1 - MAY 31, 1981



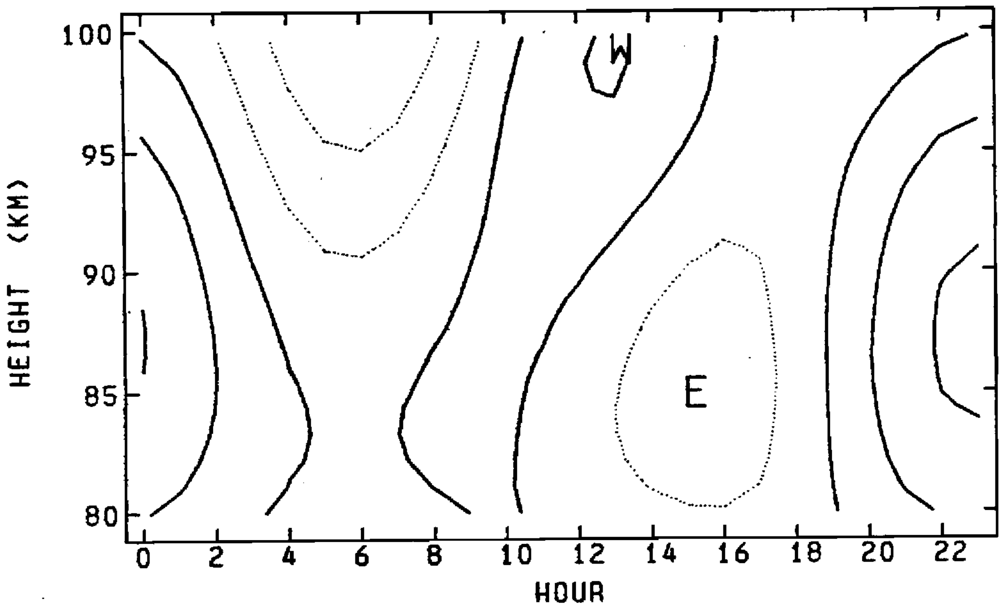
NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

MAY 1 - MAY 31 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	3.	5.	9.	7.	5.	3.	9.	7.	11.	1.
96	5.	5.	3.	6.	7.	9.	8.	6.	11.	2.
92	7.	4.	6.	6.	13.	3.	2.	5.	12.	5.
88	8.	4.	11.	7.	14.	2.	5.	5.	5.	2.
84	7.	5.	11.	8.	14.	2.	7.	6.	6.	2.
80	3.	6.	6.	7.	18.	6.	3.	8.	8.	4.

ZONAL WIND

ATLANTA (34N,84W) JUN 1 - JUN 30, 1981



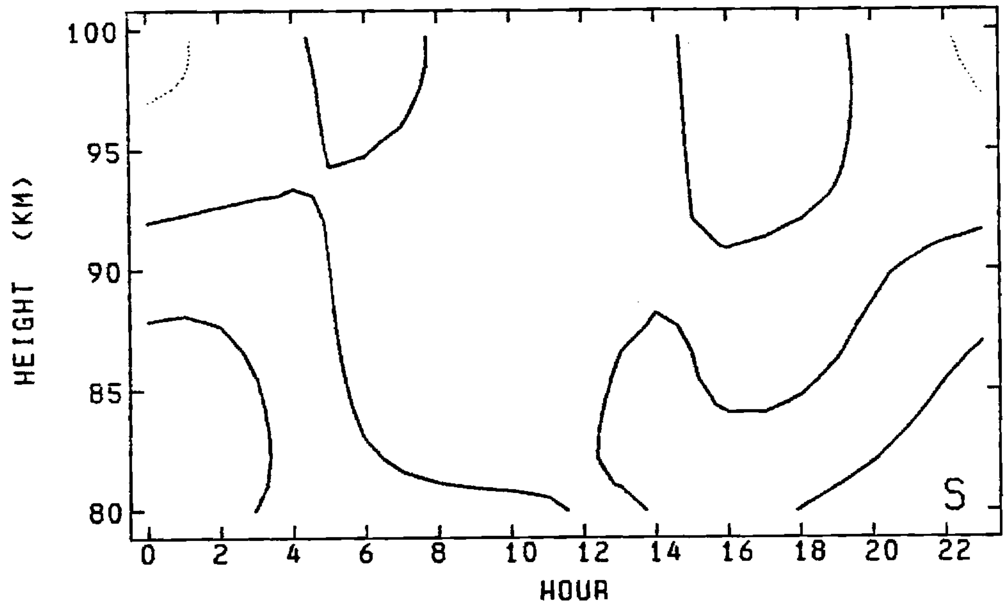
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

JUN 1 - JUN 30 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	1.	4.	12.	6.	16.	2.	12.	6.	0.	1.
96	7.	4.	8.	5.	18.	3.	12.	5.	12.	1.
92	10.	3.	7.	5.	22.	2.	11.	4.	11.	1.
88	12.	3.	11.	5.	0.	1.	10.	4.	11.	1.
84	11.	4.	12.	6.	1.	2.	8.	5.	10.	1.
80	9.	5.	4.	7.	23.	6.	5.	6.	11.	2.

MERIDIONAL WIND

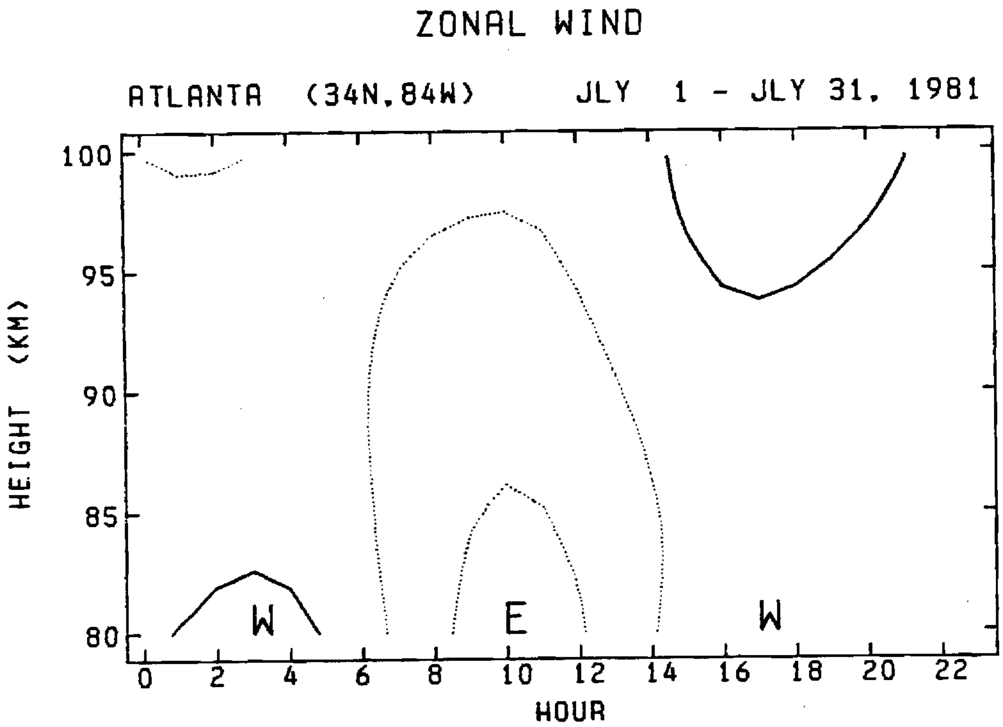
ATLANTA (34N.84W) JUN 1 - JUN 30, 1981



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JUN 1 - JUN 30 1981

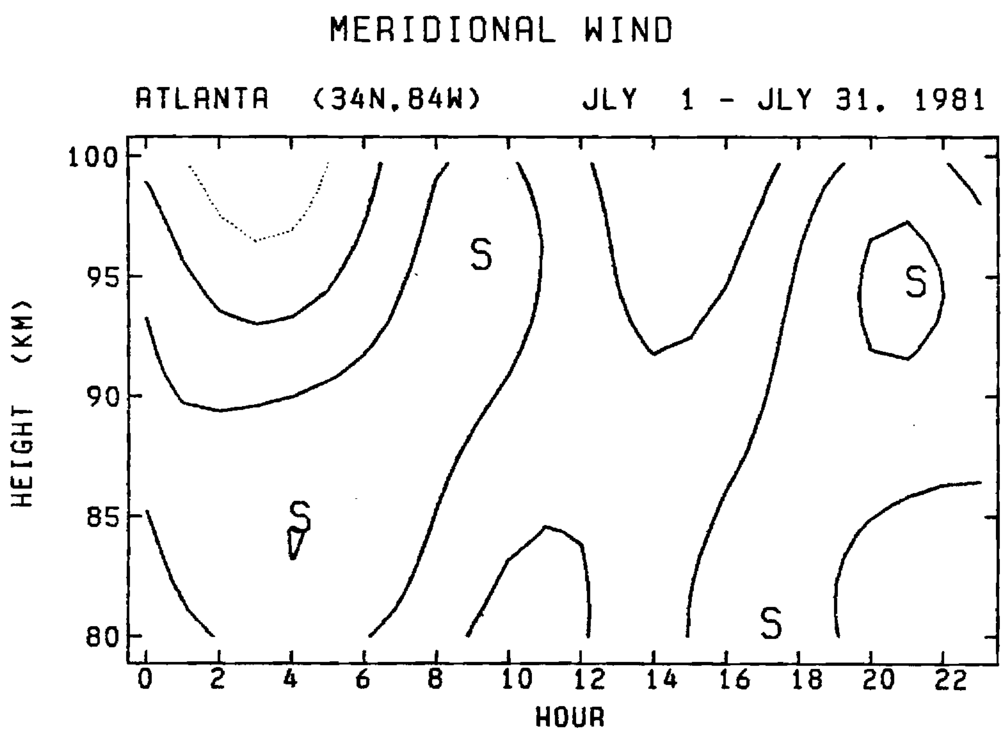
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	7.	4.	3.	6.	13.	6.	6.	5.	5.	1.
96	7.	3.	2.	5.	14.	7.	5.	4.	6.	2.
92	9.	3.	2.	4.	22.	8.	2.	4.	4.	4.
88	11.	3.	6.	5.	24.	2.	4.	4.	1.	2.
84	15.	3.	9.	5.	23.	2.	4.	5.	1.	2.
80	19.	4.	8.	6.	22.	2.	4.	5.	8.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,34W)

JLY 1 - JLY 31 1981

HEIGHT	MEAN	ERROR	24 HOUR AMP	ERROR	PHI	ERROR	12 HOUR AMP	ERROR	PHI	ERROR
100	7.	4.	7.	6.	17.	3.	6.	6.	7.	2.
96	5.	4.	5.	5.	19.	4.	3.	5.	5.	3.
92	3.	3.	4.	5.	21.	4.	4.	4.	4.	2.
88	1.	3.	5.	5.	22.	3.	5.	4.	4.	2.
84	1.	3.	7.	5.	23.	2.	6.	5.	4.	2.
80	3.	4.	11.	6.	23.	2.	8.	6.	4.	1.



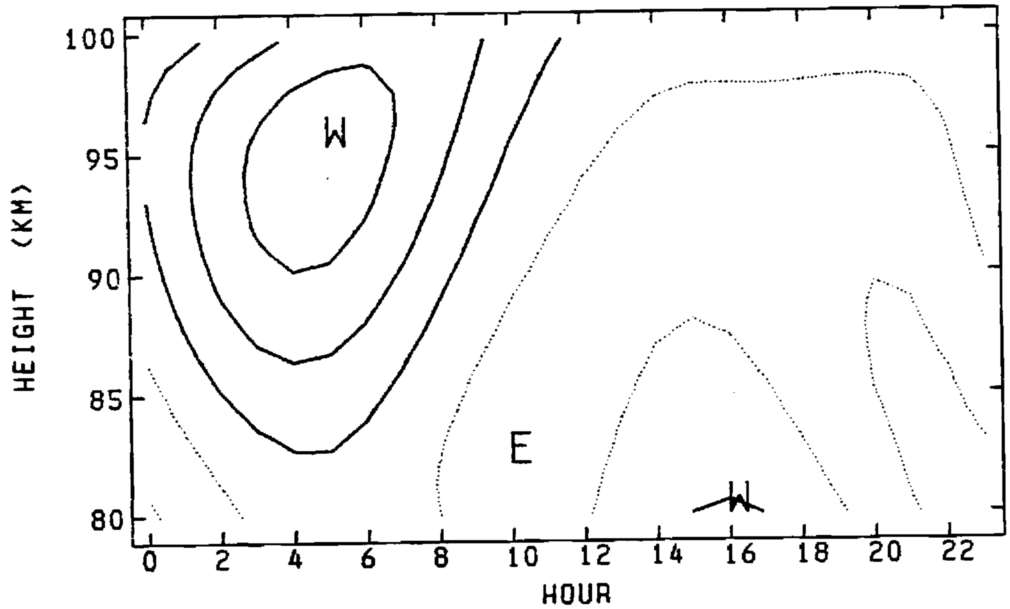
NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JLY 1 - JLY 31 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	8.	3.	4.	5.	14.	5.	12.	4.	9.	1.
96	15.	3.	4.	4.	19.	4.	13.	4.	9.	1.
92	19.	3.	4.	4.	22.	3.	8.	3.	9.	1.
88	21.	3.	5.	4.	1.	3.	4.	4.	6.	2.
84	19.	3.	5.	4.	2.	3.	7.	4.	5.	1.
80	16.	4.	4.	5.	20.	5.	5.	5.	5.	2.

ZONAL WIND

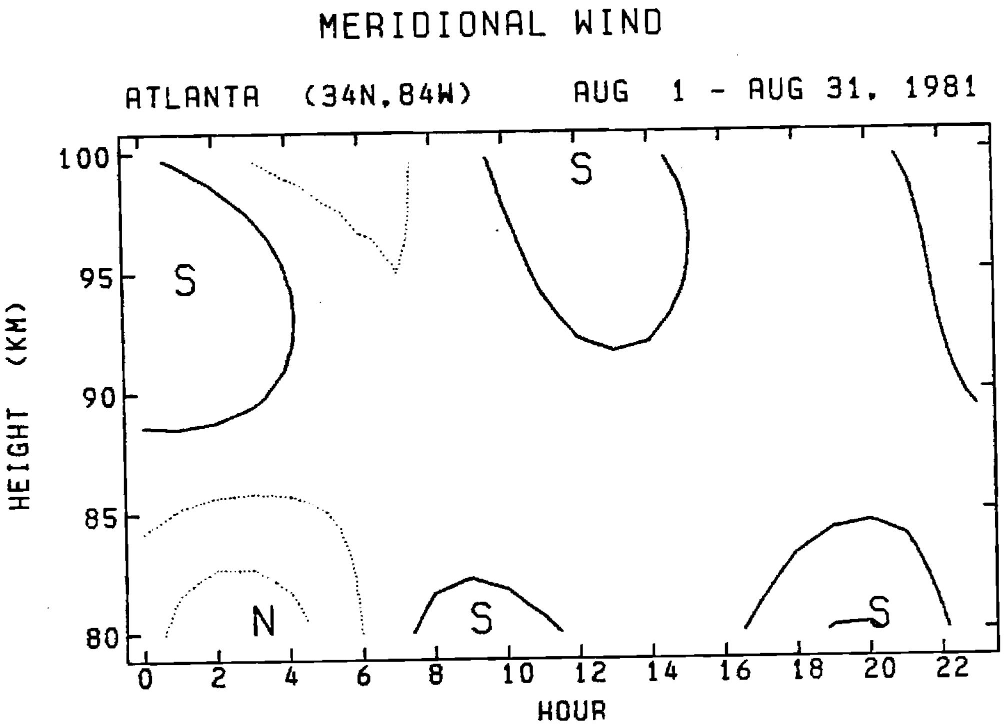
ATLANTA (34N,84W) AUG 1 - AUG 31, 1981



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

AUG 1 - AUG 31 1981

HEIGHT	MEAN	ERROR	24 HOUR AMP	ERROR	PHI	ERROR	12 HOUR AMP	ERROR	PHI	ERROR
100	10.	5.	10.	7.	8.	3.	5.	7.	7.	2.
96	11.	5.	18.	6.	5.	1.	6.	6.	5.	2.
92	8.	4.	18.	5.	5.	1.	8.	5.	4.	1.
88	3.	4.	12.	5.	5.	2.	8.	5.	4.	1.
84	0.	4.	5.	6.	7.	5.	8.	6.	4.	1.
80	1.	5.	6.	7.	13.	4.	9.	7.	5.	2.



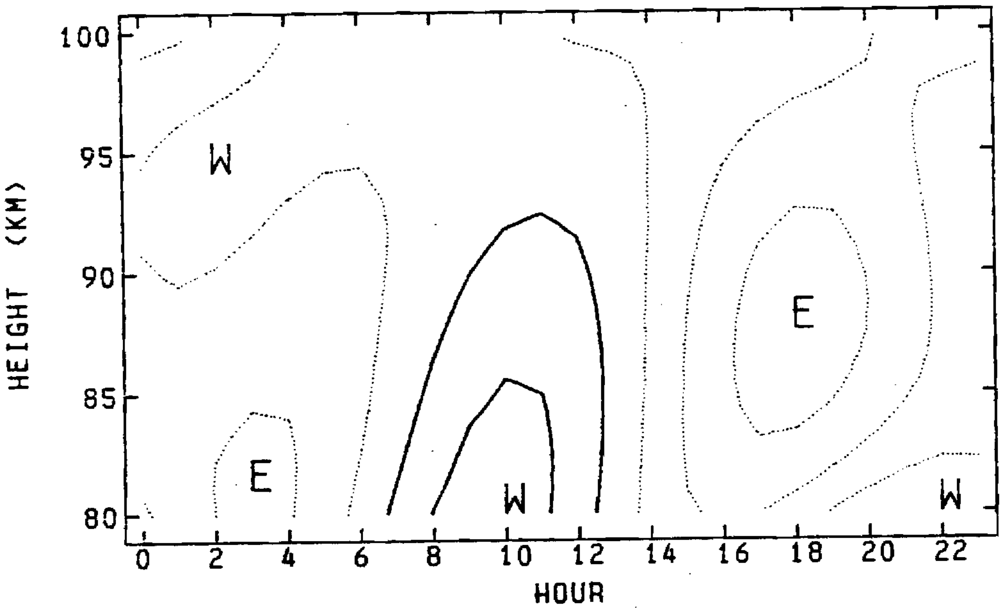
NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

AUG 1 - AUG 31 1981

HEIGHT	MEAN	ERROR	24 HOUR AMP	ERROR	PHI	ERROR	12 HOUR AMP	ERROR	PHI	ERROR
100	5.	4.	7.	6.	16.	4.	8.	6.	11.	1.
96	9.	4.	2.	6.	23.	11.	9.	6.	1.	1.
92	7.	3.	4.	5.	1.	5.	7.	5.	1.	1.
88	4.	3.	2.	5.	23.	9.	1.	5.	12.	7.
84	3.	4.	5.	5.	16.	4.	7.	5.	8.	1.
80	6.	5.	13.	7.	15.	2.	14.	7.	8.	1.

ZONAL WIND

ATLANTA (34N,84W) SEP 21 - SEP 30, 1981



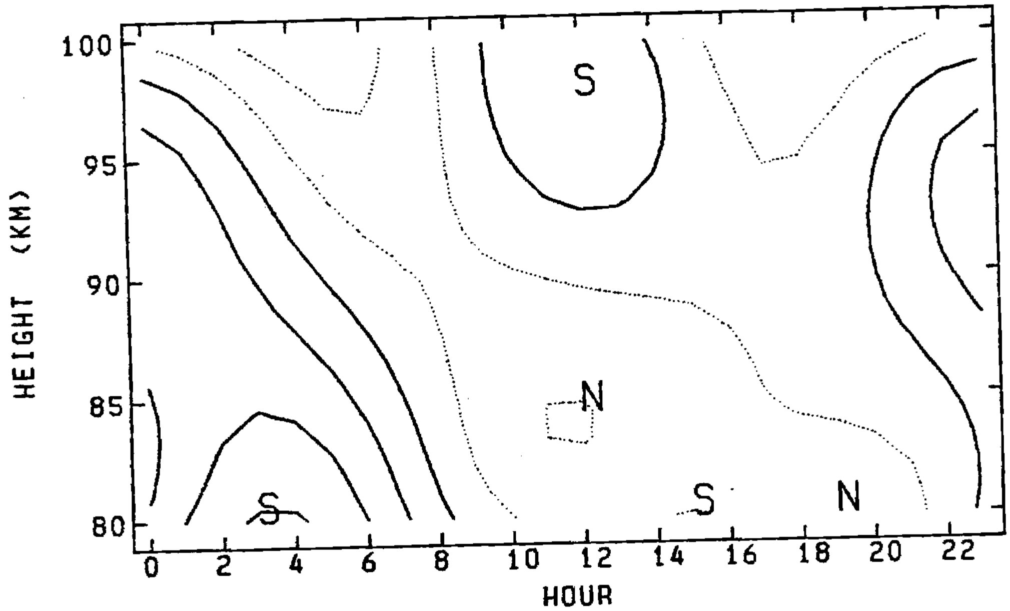
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

SEP 21 - SEP 30 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-4.	8.	9.	12.	10.	5.	6.	11.	6.	4.
96	-2.	8.	7.	11.	8.	6.	3.	10.	1.	7.
92	-3.	7.	11.	9.	8.	3.	8.	8.	12.	2.
88	-4.	7.	14.	8.	8.	3.	11.	8.	11.	2.
84	-2.	7.	13.	9.	9.	3.	12.	10.	10.	1.
80	6.	9.	5.	12.	11.	11.	16.	12.	9.	1.

MERIDIONAL WIND

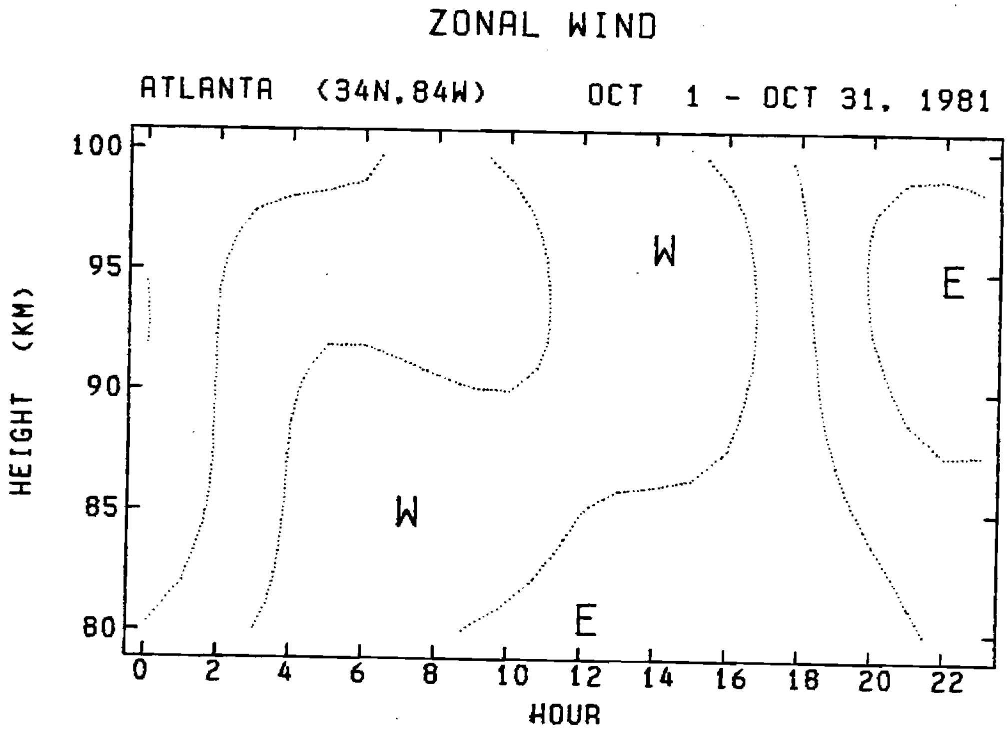
ATLANTA (34N,84W) SEP 21 - SEP 30, 1981



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

SEP 21 - SEP 30 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-5.	8.	12.	11.	12.	3.	9.	10.	11.	2.
96	7.	7.	4.	9.	19.	11.	13.	8.	12.	1.
92	9.	6.	10.	8.	23.	3.	8.	7.	0.	2.
88	8.	6.	14.	9.	1.	2.	4.	8.	2.	3.
84	7.	6.	18.	10.	3.	2.	8.	9.	4.	2.
80	14.	8.	22.	12.	4.	2.	10.	10.	3.	2.



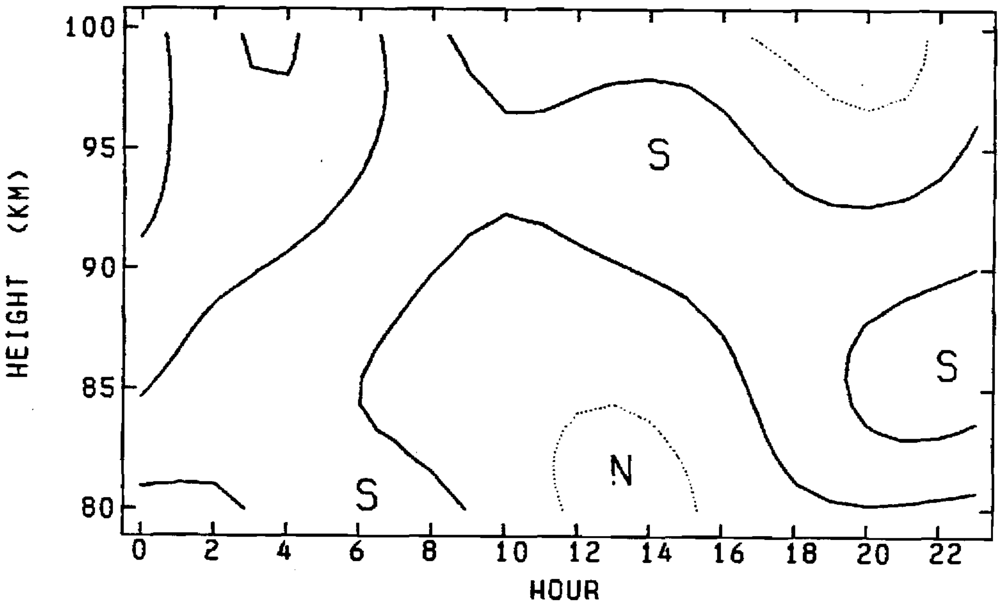
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

OCT 1 - OCT 31 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-8.	5.	12.	8.	12.	3.	5.	7.	11.	3.
96	-8.	5.	12.	7.	12.	2.	7.	7.	3.	2.
92	-6.	4.	12.	6.	11.	2.	7.	5.	4.	1.
88	-4.	4.	11.	6.	10.	2.	5.	6.	5.	2.
84	-3.	5.	9.	7.	9.	3.	4.	7.	6.	3.
80	-3.	6.	2.	9.	8.	15.	6.	8.	5.	3.

MERIDIONAL WIND

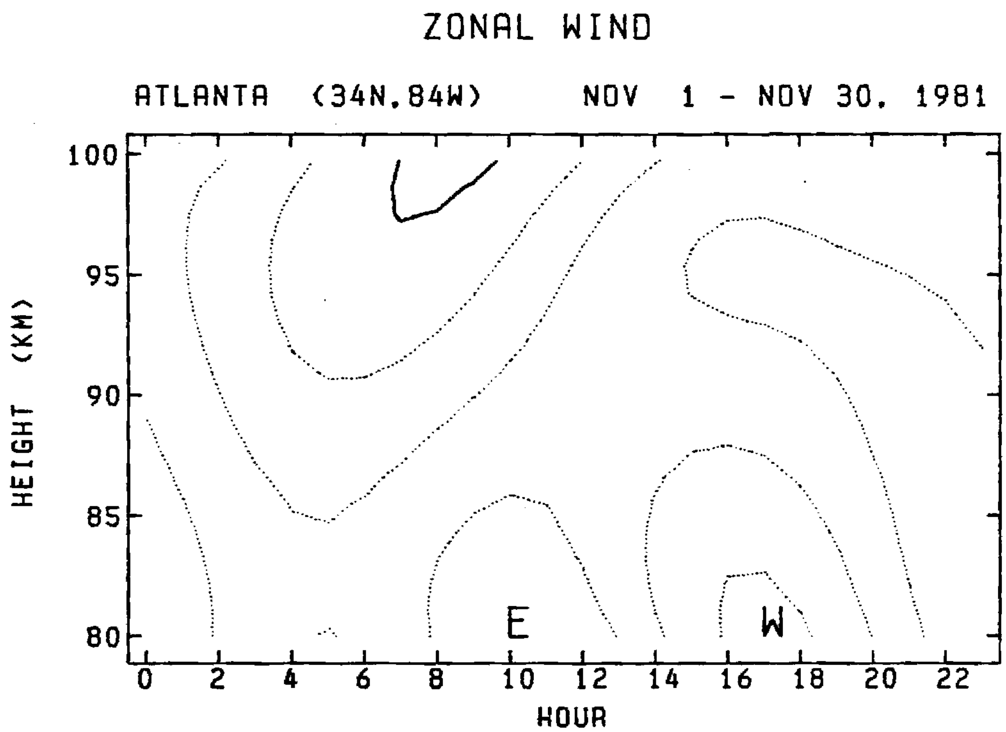
ATLANTA (34N.84W) OCT 1 - OCT 31, 1981



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

OCT 1 - OCT 31 1981

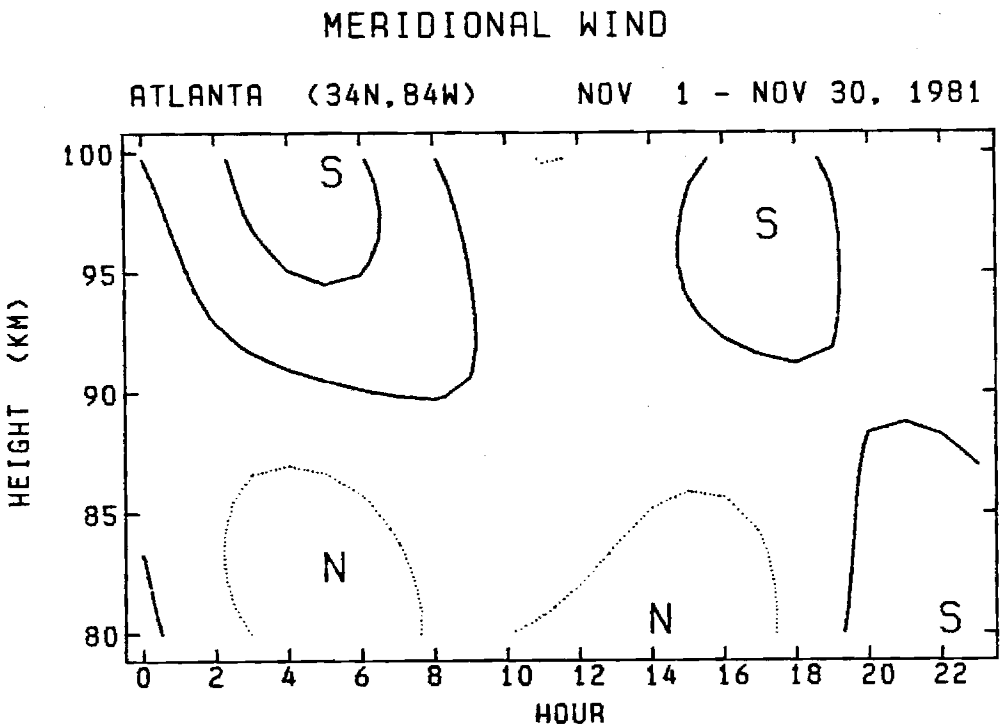
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	8.	5.	17.	7.	4.	2.	7.	6.	3.	2.
96	13.	5.	9.	6.	5.	3.	7.	6.	3.	2.
92	15.	4.	5.	5.	2.	4.	3.	5.	3.	3.
88	14.	4.	9.	6.	23.	2.	1.	5.	9.	13.
84	10.	5.	9.	7.	23.	2.	4.	6.	8.	3.
80	6.	6.	8.	7.	6.	4.	6.	8.	6.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

NOV 1 - NOV 30 1981

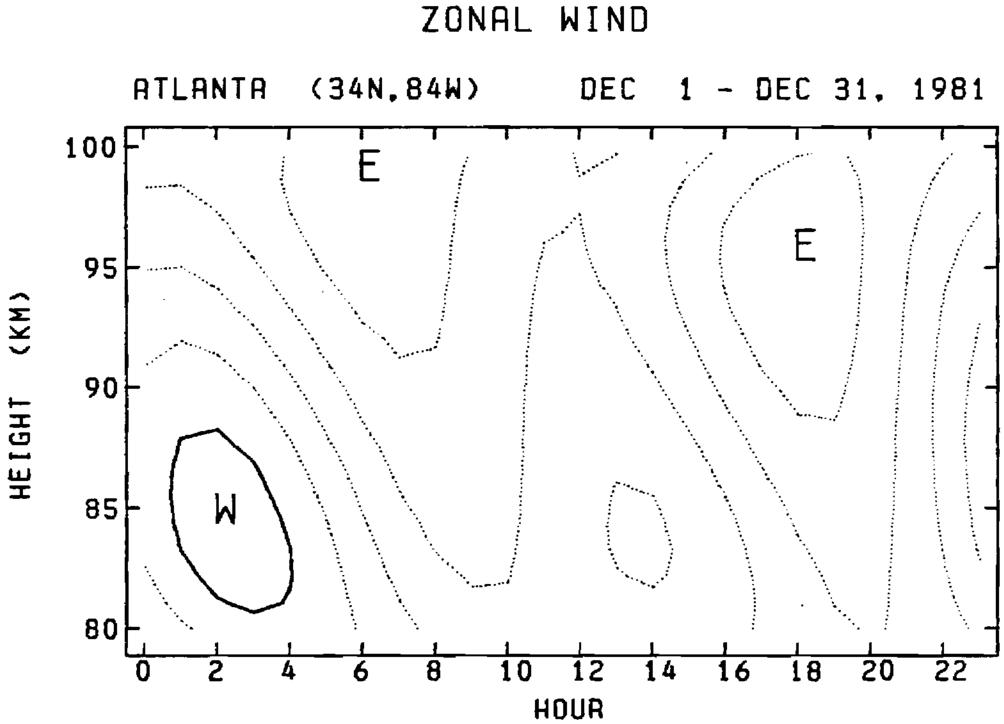
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-4.	5.	12.	7.	9.	2.	5.	8.	9.	2.
96	-9.	5.	15.	6.	7.	2.	4.	6.	7.	4.
92	-12.	4.	11.	5.	6.	2.	4.	6.	5.	3.
88	-14.	4.	4.	6.	9.	6.	7.	6.	4.	2.
84	-15.	5.	5.	6.	16.	5.	10.	7.	5.	1.
80	-15.	5.	6.	7.	19.	5.	14.	7.	5.	1.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

NOV 1 - NOV 30 1981

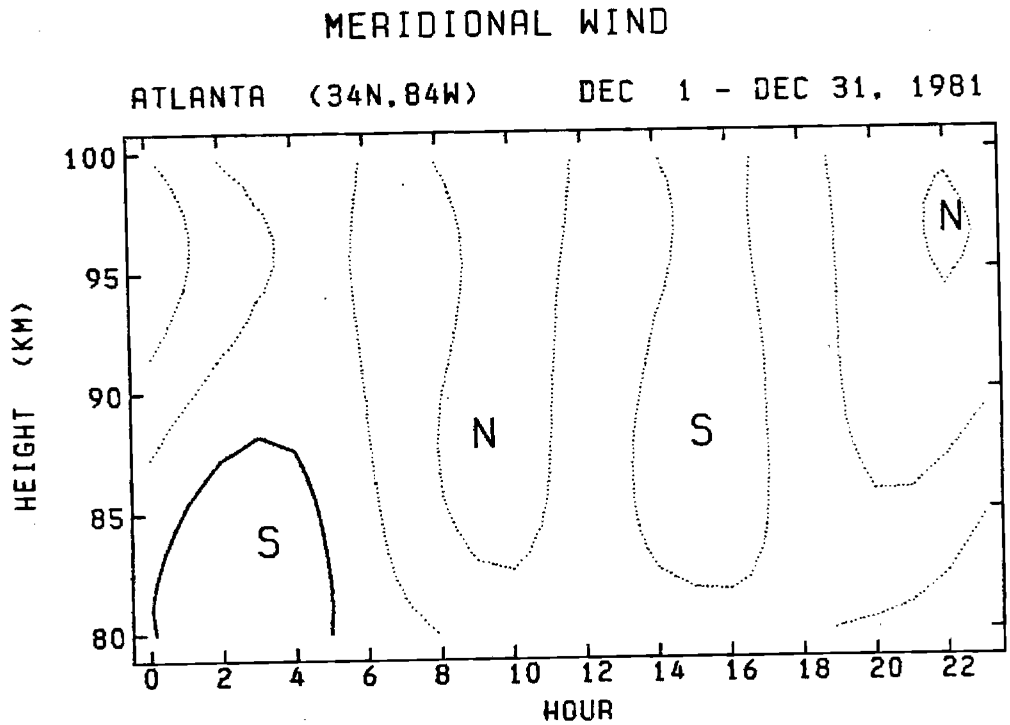
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	10.	5.	8.	7.	2.	3.	7.	7.	4.	2.
96	11.	4.	5.	6.	5.	5.	7.	6.	5.	1.
92	9.	4.	2.	5.	6.	11.	3.	5.	6.	3.
88	6.	4.	1.	5.	20.	15.	4.	5.	9.	3.
84	3.	4.	5.	6.	21.	5.	7.	6.	10.	2.
80	2.	5.	10.	8.	23.	3.	6.	7.	9.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

DEC 1 - DEC 31 1981

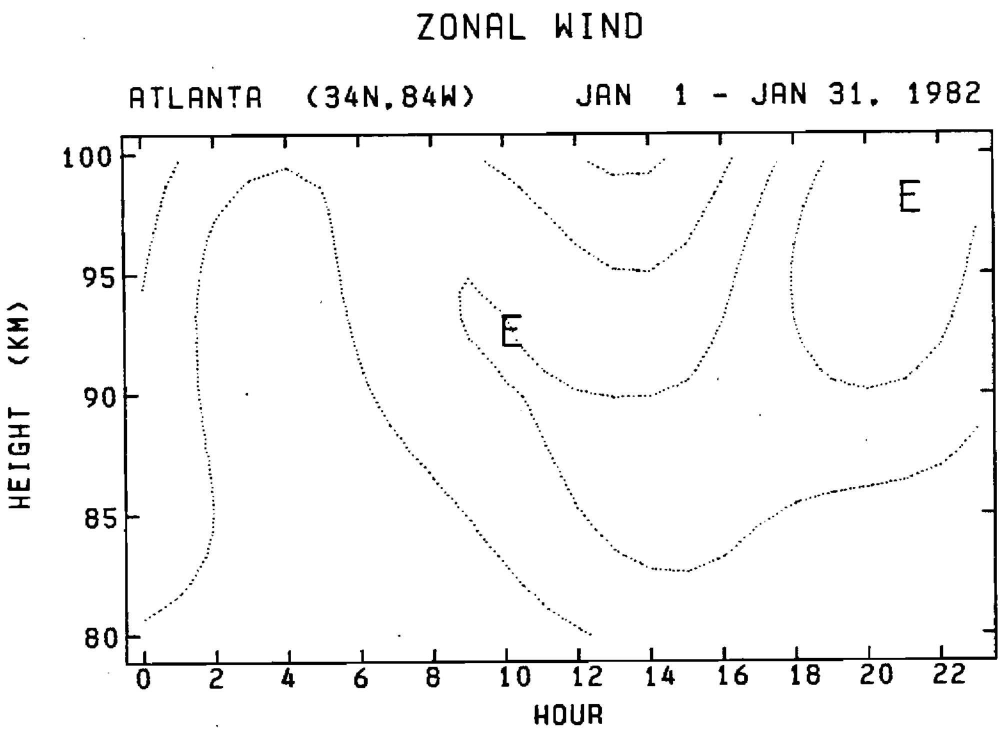
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-29.	5.	4.	7.	11.	6.	8.	7.	1.	2.
96	-29.	4.	6.	6.	4.	4.	12.	6.	0.	1.
92	-23.	4.	11.	5.	3.	2.	14.	5.	1.	1.
88	-16.	4.	13.	5.	3.	2.	16.	5.	1.	1.
84	-12.	4.	13.	6.	4.	2.	15.	6.	2.	1.
80	-15.	5.	13.	6.	6.	2.	7.	7.	4.	2.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

DEC 1 - DEC 31 1981

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-6.	4.	3.	5.	5.	8.	12.	6.	3.	1.
96	-8.	4.	4.	6.	10.	5.	9.	5.	4.	1.
92	-6.	3.	3.	4.	9.	6.	9.	4.	4.	1.
88	-3.	3.	3.	5.	3.	5.	10.	5.	3.	1.
84	1.	4.	8.	5.	2.	2.	9.	5.	3.	1.
80	2.	4.	9.	6.	2.	3.	2.	6.	7.	6.



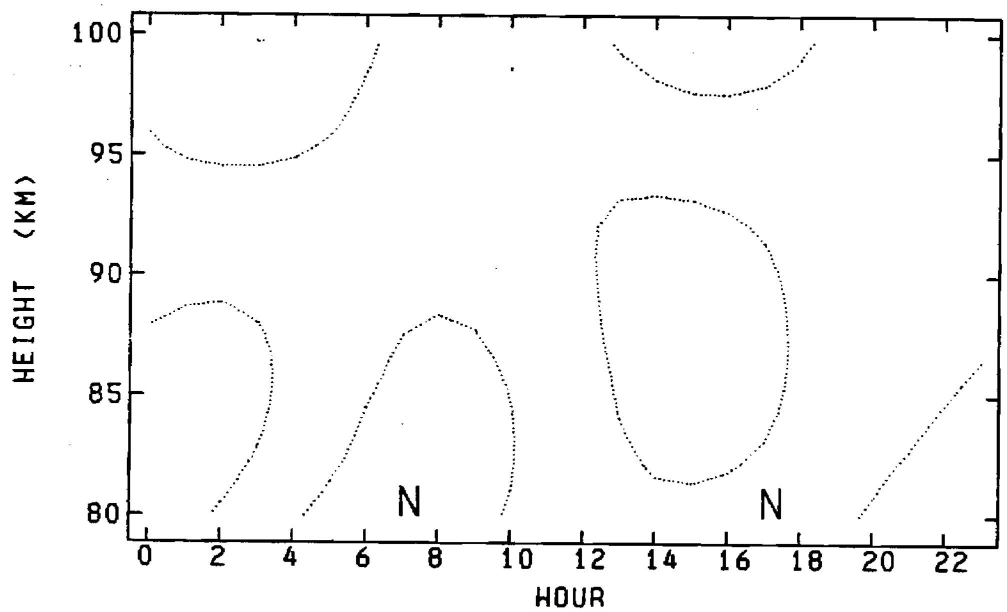
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

JAN 1 - JAN 31 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-24.	5.	16.	6.	11.	2.	7.	6.	3.	2.
96	-28.	4.	11.	5.	8.	2.	11.	6.	3.	1.
92	-29.	4.	9.	5.	6.	2.	8.	5.	3.	1.
88	-27.	4.	9.	5.	5.	2.	3.	5.	4.	4.
84	-22.	4.	8.	6.	5.	3.	3.	6.	7.	3.
80	-17.	5.	8.	7.	7.	3.	1.	6.	0.	23.

MERIDIONAL WIND

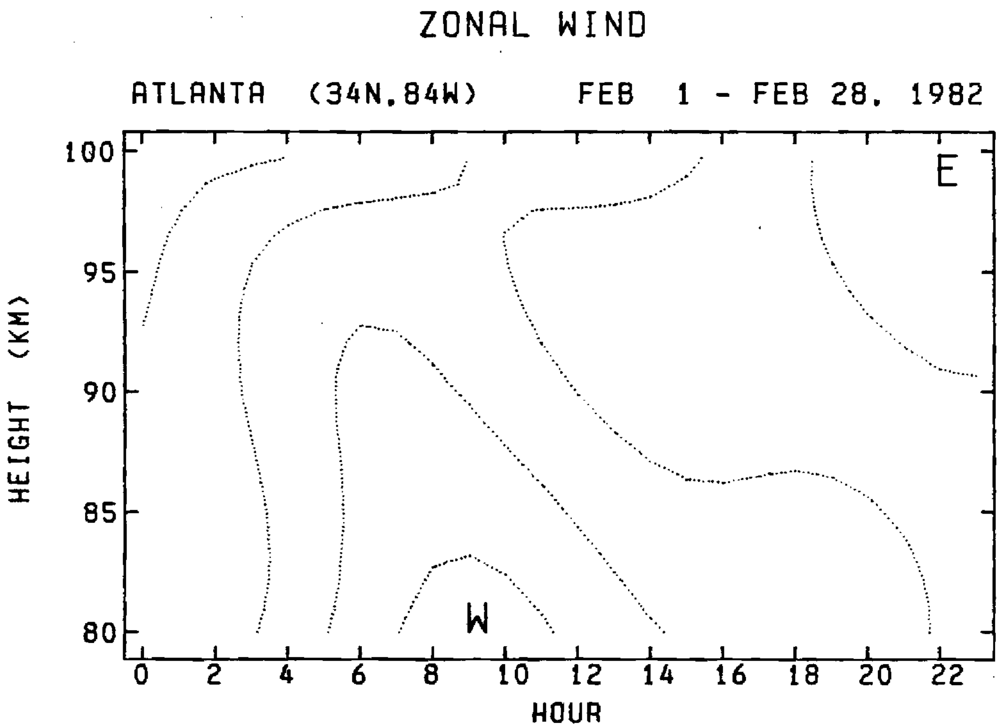
ATLANTA (34N,84W) JAN 1 - JAN 31, 1982



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JAN 1 - JAN 31 1982

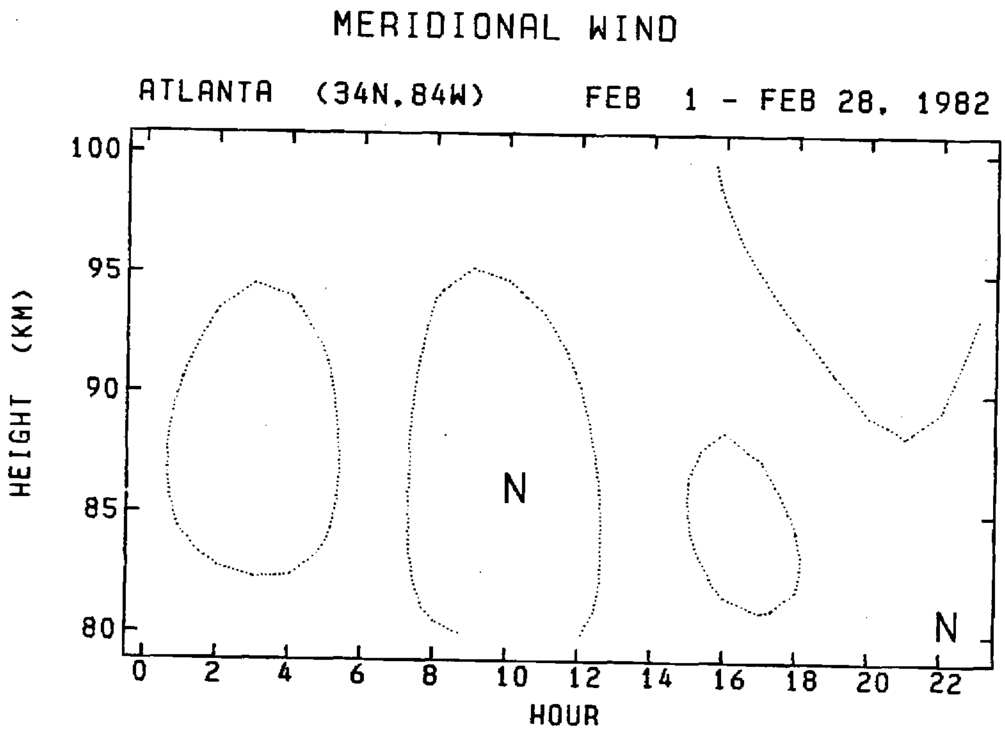
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-21.	4.	0.	5.	11.	72.	11.	5.	9.	1.
96	-17.	3.	4.	5.	13.	4.	4.	4.	9.	2.
92	-14.	3.	3.	4.	15.	4.	2.	4.	2.	4.
88	-12.	3.	4.	4.	19.	4.	5.	4.	2.	1.
84	-13.	3.	6.	4.	21.	3.	5.	4.	2.	1.
80	-15.	4.	8.	5.	20.	3.	4.	5.	12.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,34W)

FEB 1 - FEB 28 1982

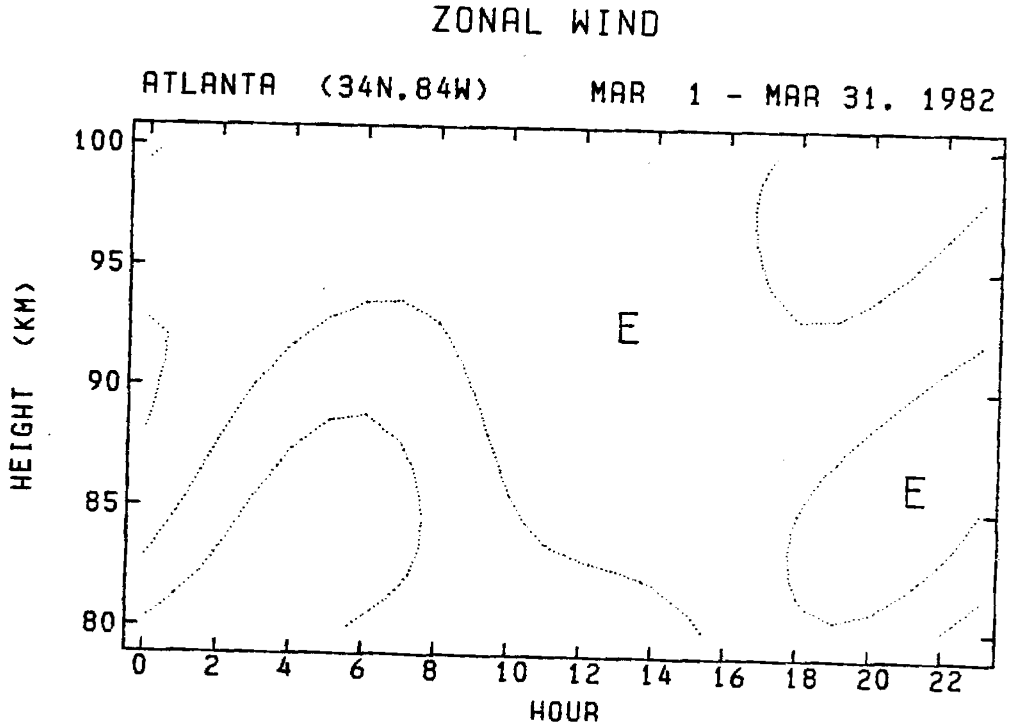
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-27.	5.	12.	8.	13.	2.	4.	7.	0.	4.
96	-25.	5.	8.	6.	9.	3.	3.	6.	5.	4.
92	-22.	4.	9.	5.	8.	2.	4.	5.	6.	2.
88	-18.	4.	9.	5.	9.	2.	5.	5.	7.	2.
84	-14.	4.	10.	6.	10.	2.	5.	6.	8.	2.
80	-11.	5.	13.	7.	10.	2.	4.	7.	8.	3.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

FEB 1 - FEB 28 1982

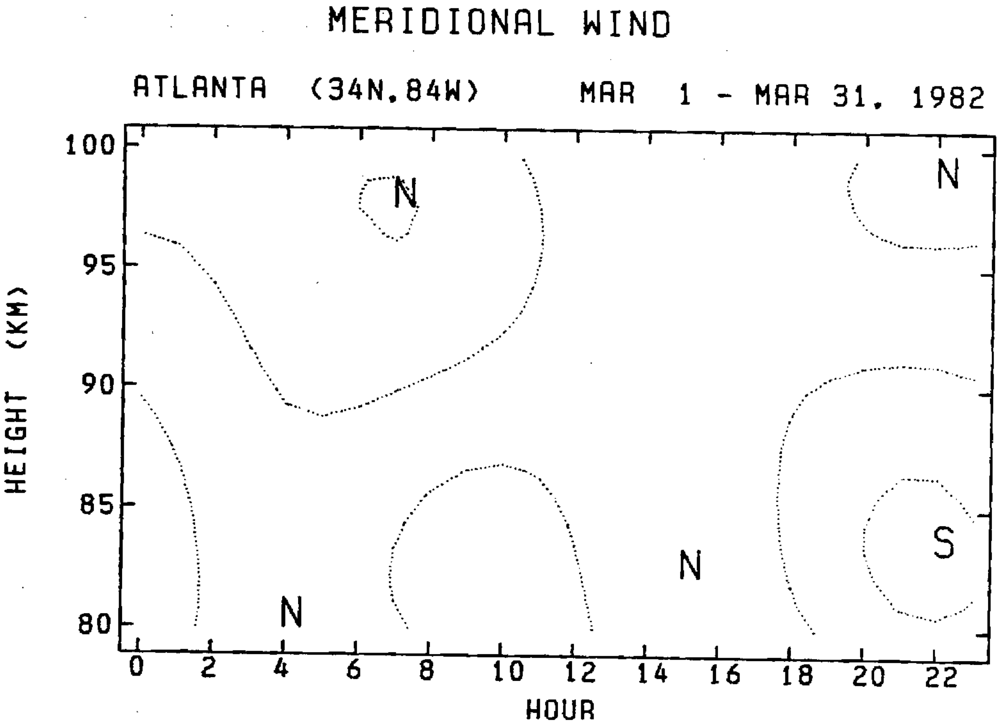
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-20.	4.	5.	5.	7.	4.	4.	5.	2.	2.
96	-19.	4.	5.	5.	7.	4.	5.	5.	2.	2.
92	-17.	3.	3.	4.	4.	5.	7.	4.	3.	1.
88	-15.	3.	5.	4.	24.	4.	6.	4.	3.	1.
84	-15.	3.	5.	5.	22.	4.	7.	5.	4.	1.
80	-18.	4.	4.	6.	15.	6.	3.	6.	7.	4.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

MAR 1 - MAR 31 1982

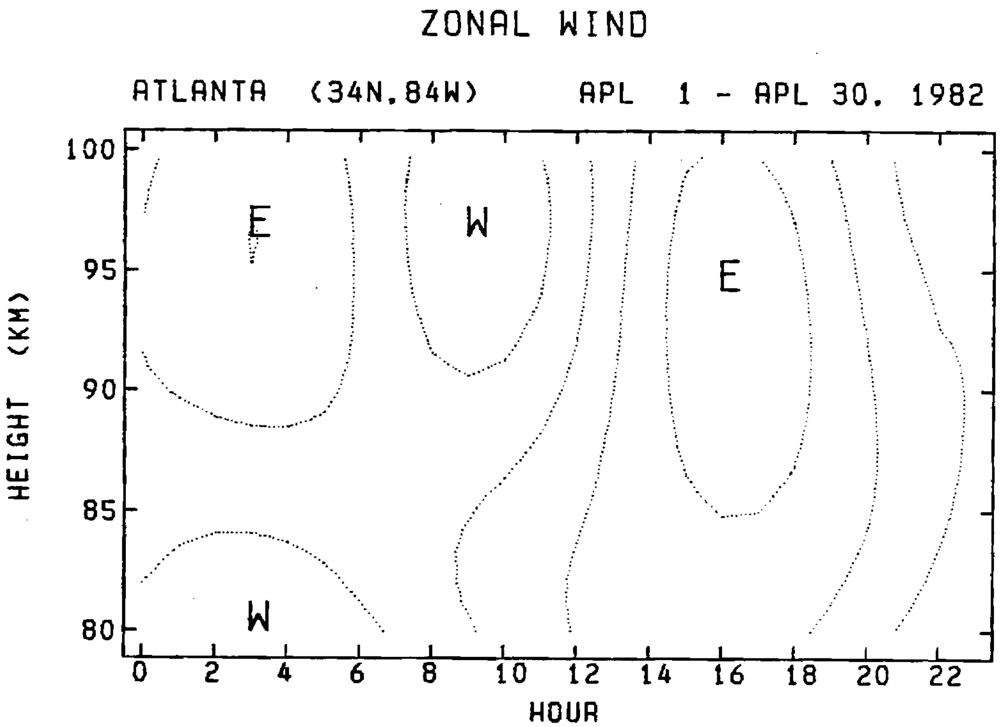
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-21.	4.	3.	6.	19.	7.	4.	6.	11.	3.
96	-24.	4.	4.	6.	19.	5.	4.	6.	8.	3.
92	-25.	3.	2.	5.	7.	8.	6.	5.	6.	2.
88	-23.	3.	10.	5.	6.	2.	6.	5.	5.	2.
84	-19.	4.	13.	5.	6.	2.	5.	5.	4.	2.
80	-14.	4.	7.	6.	4.	4.	8.	6.	1.	1.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

MAR 1 - MAR 31 1982

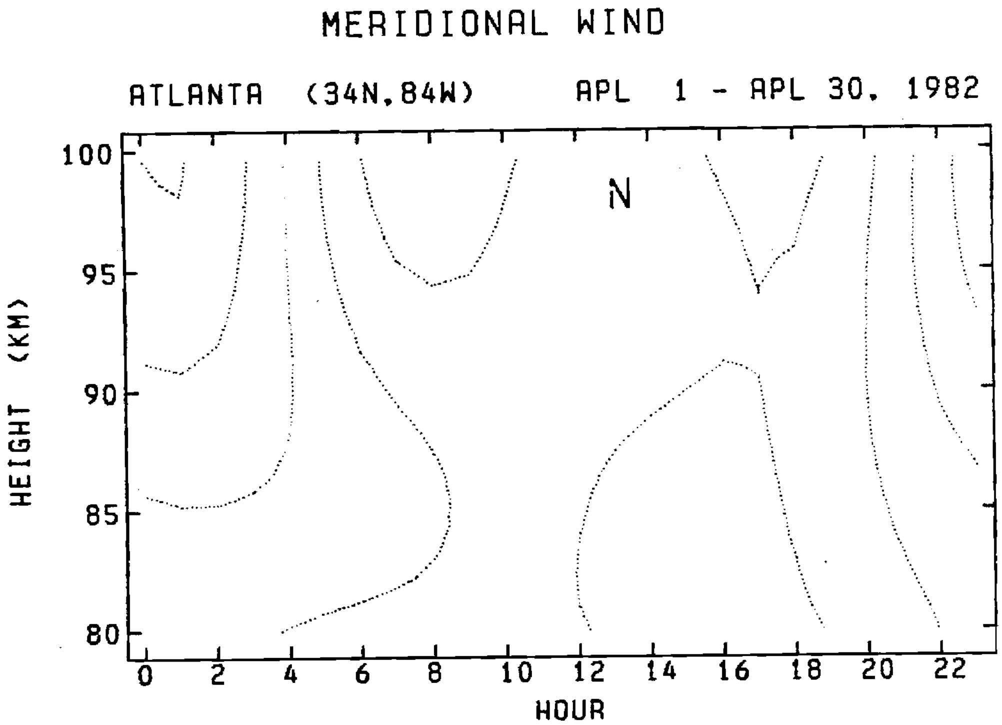
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-20.	3.	6.	5.	16.	3.	3.	5.	1.	3.
96	-21.	3.	7.	4.	17.	2.	4.	5.	2.	2.
92	-17.	3.	6.	4.	18.	2.	2.	4.	0.	4.
88	-12.	3.	5.	3.	20.	3.	5.	3.	10.	1.
84	-9.	3.	4.	4.	22.	4.	8.	4.	10.	1.
80	-11.	4.	1.	5.	23.	18.	6.	5.	10.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

APL 1 - APL 30 1982

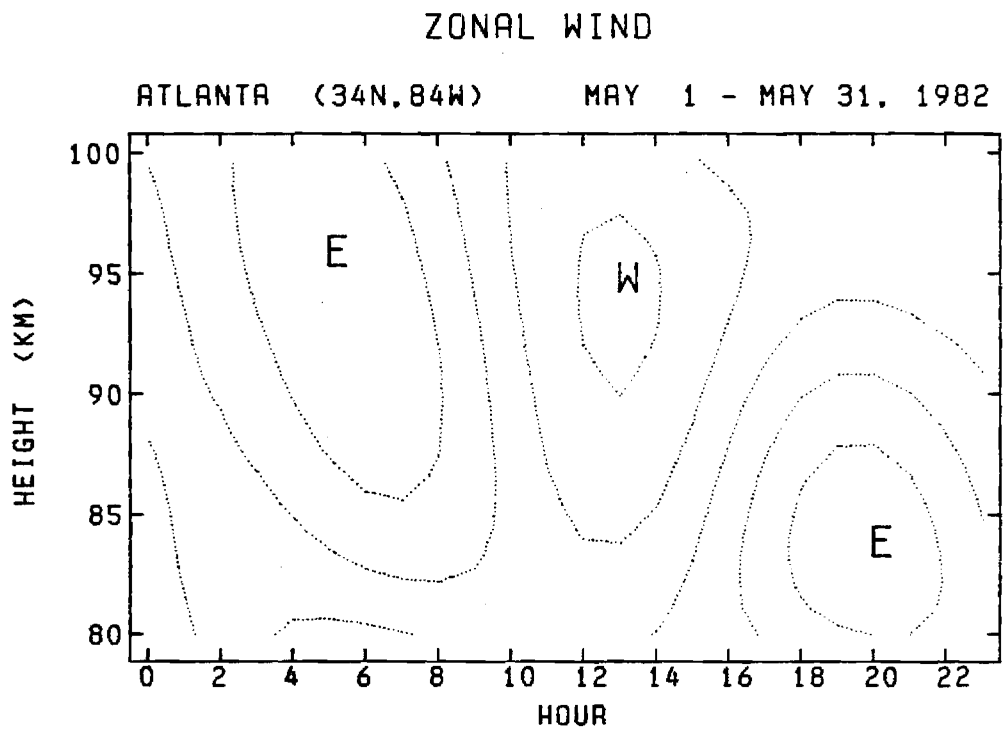
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-12.	5.	8.	7.	6.	3.	10.	7.	10.	1.
96	-14.	4.	11.	6.	7.	2.	14.	6.	10.	1.
92	-15.	4.	12.	5.	6.	2.	11.	5.	10.	1.
88	-15.	4.	13.	5.	5.	2.	6.	5.	10.	2.
84	-13.	4.	15.	6.	3.	2.	2.	6.	12.	7.
80	-8.	5.	18.	7.	3.	2.	1.	7.	10.	12.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

APL 1 - APL 30 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-20.	4.	18.	5.	13.	1.	13.	5.	7.	1.
96	-22.	3.	16.	5.	12.	1.	11.	5.	7.	1.
92	-22.	3.	14.	4.	13.	1.	7.	4.	7.	1.
88	-20.	3.	13.	4.	14.	1.	2.	4.	6.	3.
84	-18.	3.	11.	5.	15.	2.	2.	5.	4.	5.
80	-14.	4.	7.	6.	14.	3.	4.	6.	6.	3.



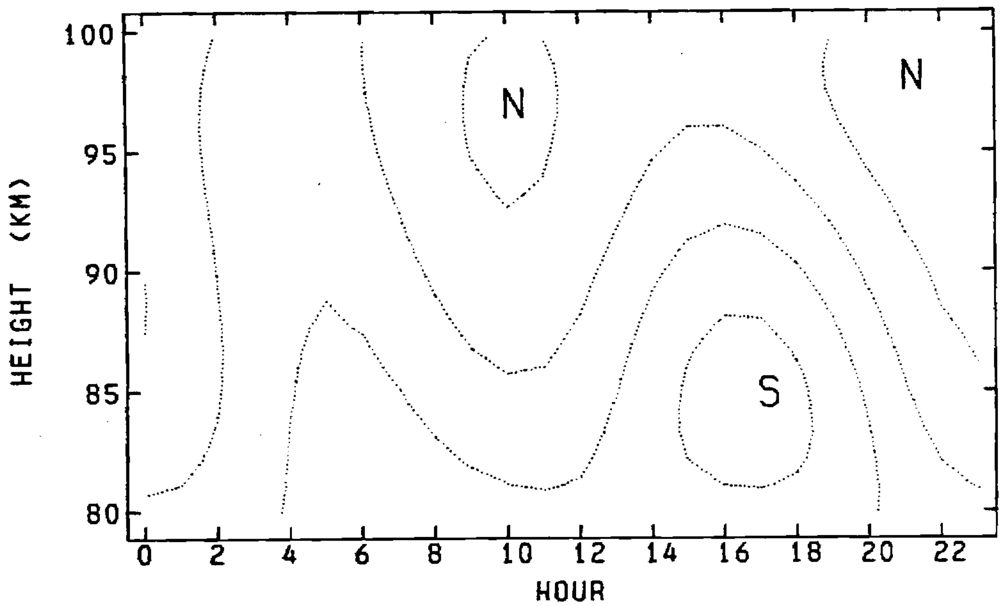
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

MAY 1 - MAY 31 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-19.	6.	10.	8.	14.	4.	6.	8.	11.	3.
96	-17.	6.	14.	8.	15.	2.	8.	8.	12.	2.
92	-20.	5.	12.	7.	15.	2.	11.	7.	1.	1.
88	-24.	5.	8.	8.	11.	3.	13.	8.	1.	1.
84	-25.	6.	12.	8.	8.	3.	11.	8.	2.	1.
80	-20.	7.	14.	9.	7.	3.	5.	9.	5.	4.

MERIDIONAL WIND

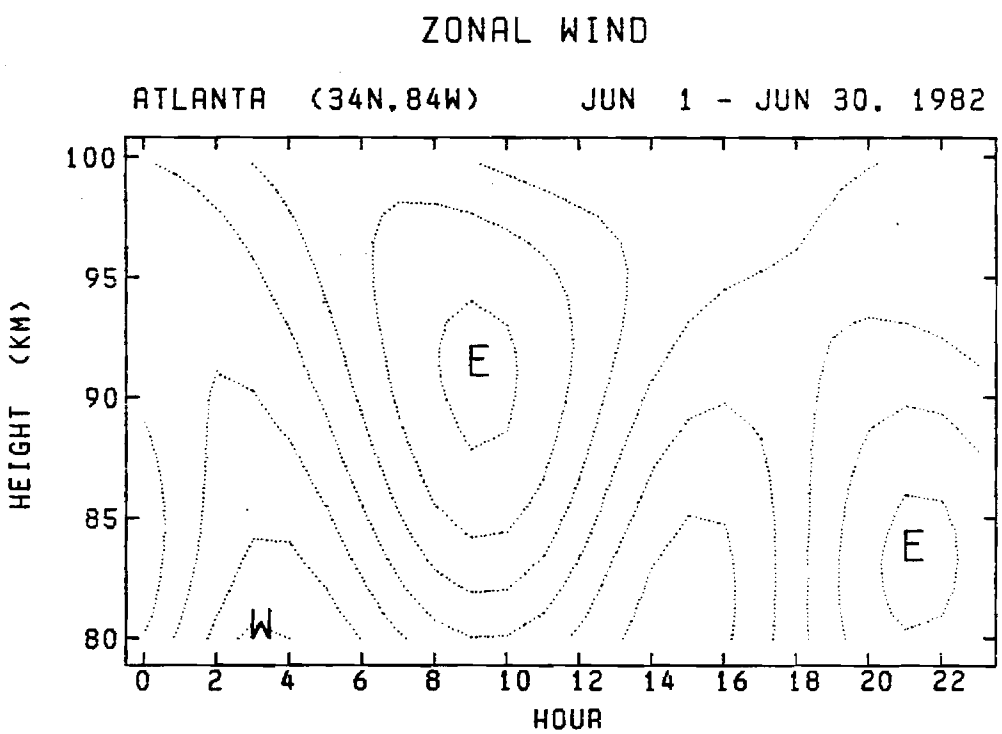
ATLANTA (34N,84W) MAY 1 - MAY 31, 1982



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

MAY 1 - MAY 31 1982

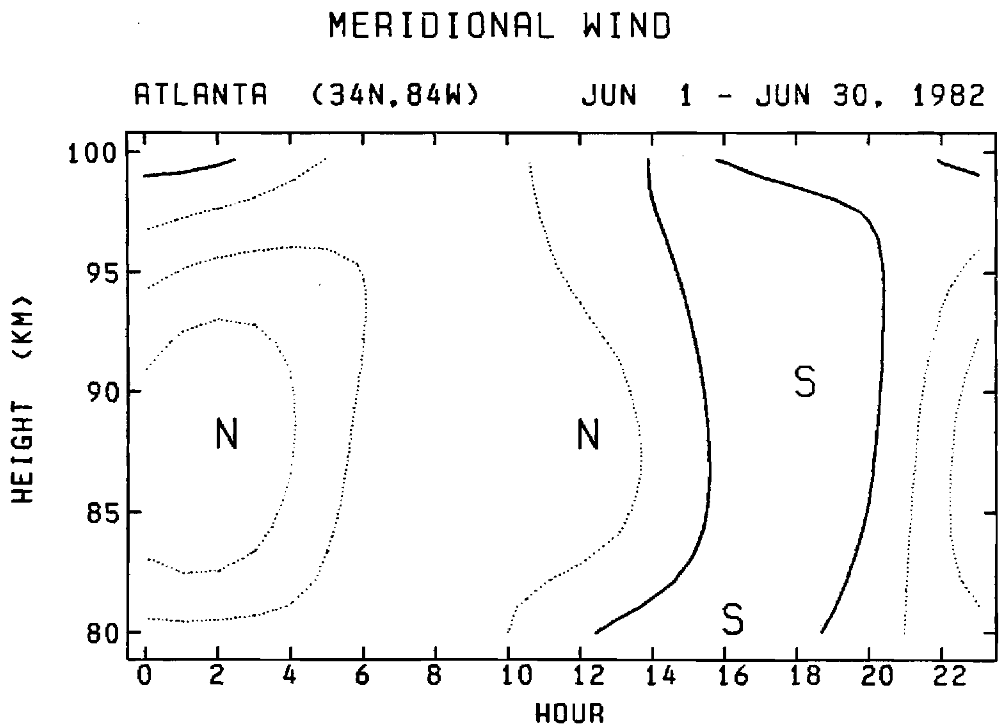
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-25.	5.	3.	7.	7.	10.	6.	6.	4.	2.
96	-25.	4.	3.	6.	5.	7.	8.	6.	4.	2.
92	-21.	4.	2.	5.	12.	10.	10.	5.	4.	1.
88	-16.	4.	7.	6.	14.	3.	12.	5.	5.	1.
84	-11.	4.	8.	7.	14.	3.	10.	6.	5.	1.
80	-9.	5.	4.	8.	10.	7.	2.	7.	7.	7.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,34W)

JUN 1 - JUN 30 1982

HEIGHT	MEAN	ERROR	24 HOUR AMP	24 HOUR ERROR	24 HOUR PHI	24 HOUR ERROR	12 HOUR AMP	12 HOUR ERROR	12 HOUR PHI	12 HOUR ERROR
100	-35.	5.	7.	7.	16.	4.	5.	7.	11.	3.
96	-36.	5.	15.	7.	21.	2.	5.	7.	2.	3.
92	-36.	4.	15.	6.	22.	2.	11.	6.	3.	1.
88	-34.	5.	7.	6.	21.	4.	19.	6.	3.	1.
84	-29.	5.	4.	7.	10.	8.	22.	7.	3.	1.
80	-18.	6.	12.	8.	8.	3.	16.	8.	3.	1.



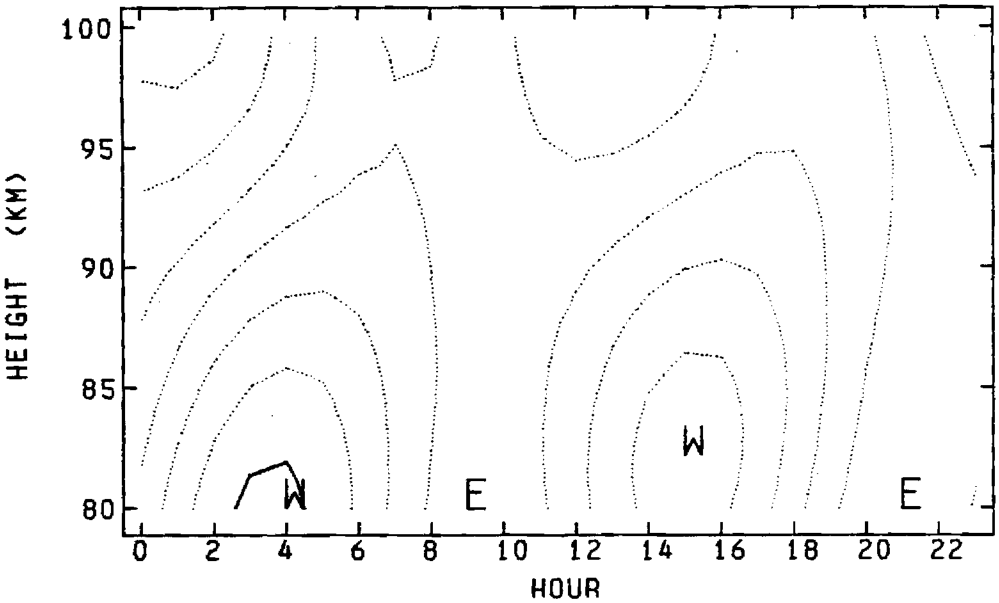
NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JUN 1 - JUN 30 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	7.	5.	7.	7.	22.	4.	7.	7.	1.	2.
96	2.	5.	12.	6.	17.	2.	1.	6.	5.	13.
92	-3.	4.	16.	6.	16.	1.	8.	5.	7.	1.
88	-4.	4.	17.	6.	15.	1.	11.	6.	7.	1.
84	-3.	4.	15.	7.	15.	2.	8.	6.	7.	1.
80	4.	5.	12.	8.	16.	2.	7.	7.	2.	2.

ZONAL WIND

ATLANTA (34N,84W) JLY 1 - JLY 31, 1982



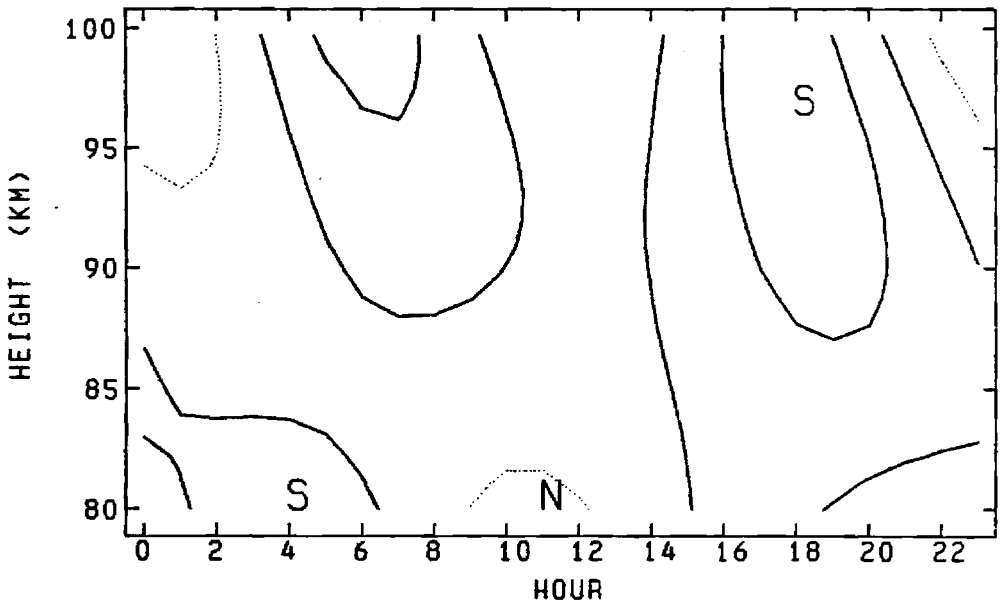
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

JLY 1 - JLY 31 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-35.	6.	9.	9.	12.	3.	14.	8.	7.	1.
96	-31.	5.	7.	8.	12.	4.	10.	7.	7.	1.
92	-24.	4.	6.	6.	12.	3.	8.	6.	5.	1.
88	-18.	4.	6.	7.	11.	4.	13.	6.	4.	1.
84	-13.	5.	7.	7.	9.	4.	19.	7.	4.	1.
80	-13.	6.	8.	8.	6.	4.	21.	8.	3.	1.

MERIDIONAL WIND

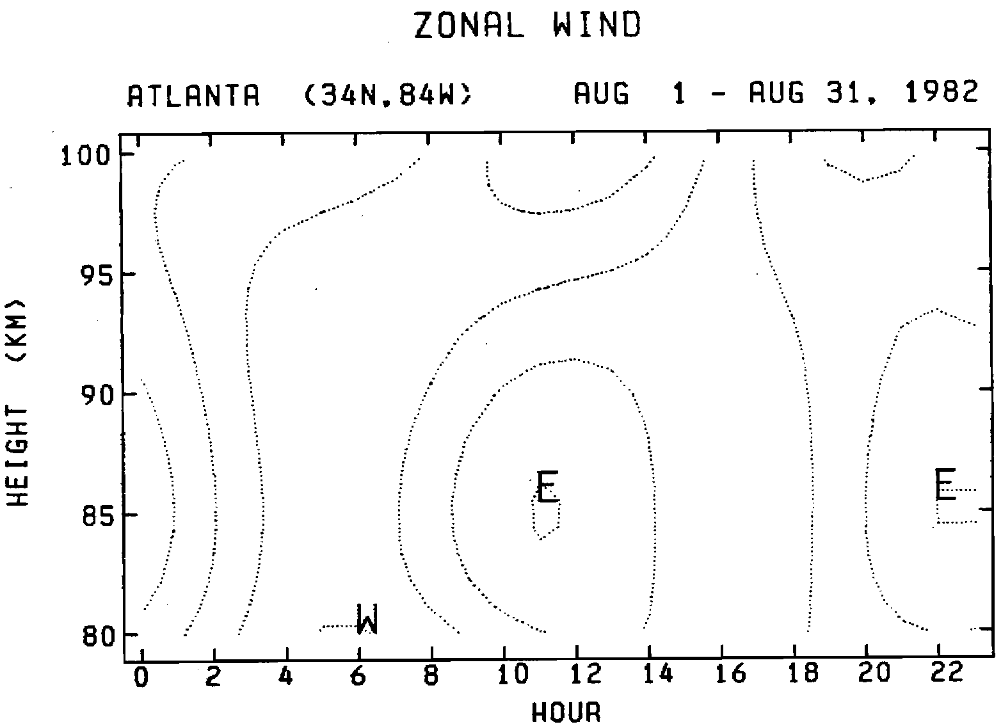
ATLANTA (34N,84W) JLY 1 - JLY 31, 1982



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JLY 1 - JLY 31 1982

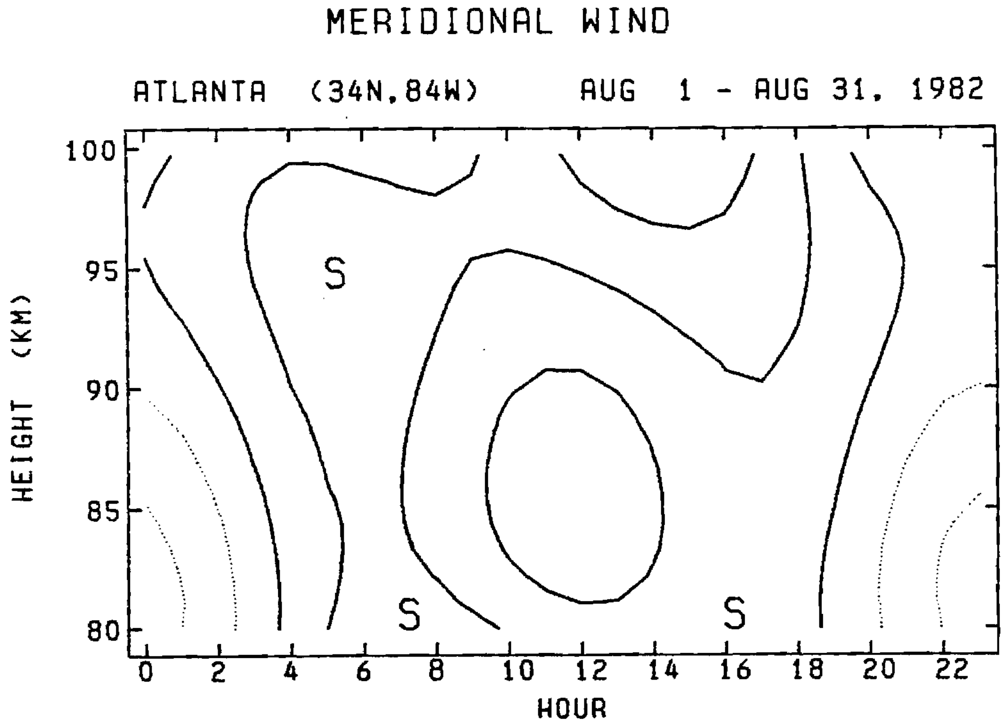
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	9.	5.	4.	7.	11.	6.	15.	7.	6.	1.
96	11.	4.	5.	6.	14.	4.	11.	6.	6.	1.
92	12.	3.	5.	5.	17.	3.	7.	5.	7.	1.
88	11.	4.	6.	5.	19.	4.	4.	5.	7.	2.
84	9.	4.	5.	6.	21.	5.	3.	6.	5.	4.
80	6.	5.	3.	7.	2.	8.	9.	7.	4.	1.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

AUG 1 - AUG 31 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-16.	6.	18.	9.	11.	2.	10.	9.	1.	1.
96	-14.	5.	12.	7.	9.	2.	2.	7.	2.	7.
92	-17.	4.	10.	6.	8.	2.	8.	6.	5.	2.
88	-21.	5.	8.	6.	8.	3.	13.	6.	5.	1.
84	-21.	5.	7.	7.	8.	4.	13.	7.	5.	1.
80	-14.	6.	12.	8.	7.	3.	6.	9.	6.	3.



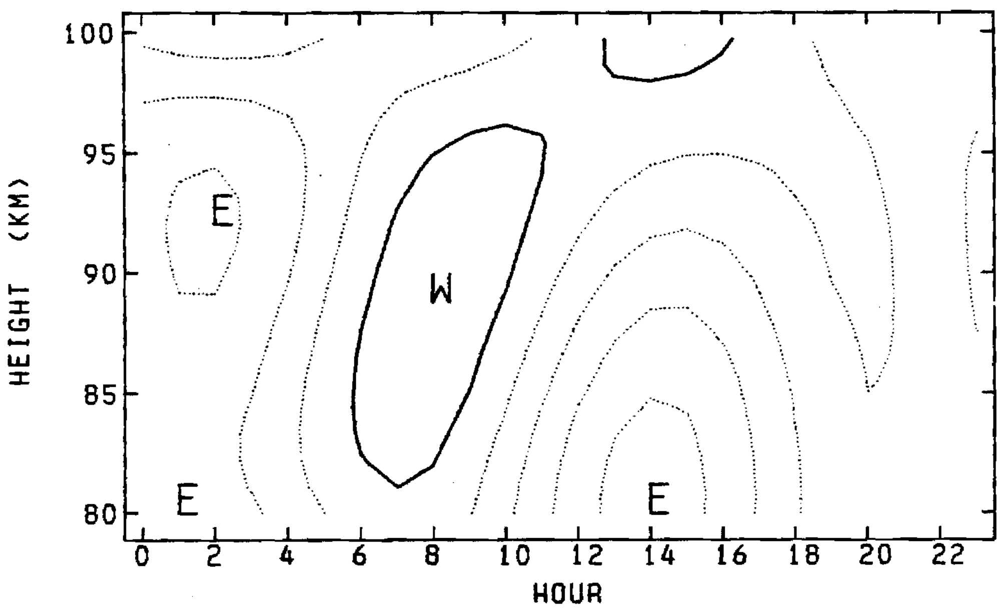
NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

AUG 1 - AUG 31 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	19.	5.	16.	8.	13.	2.	10.	7.	3.	1.
96	20.	5.	7.	7.	12.	3.	6.	6.	4.	2.
92	16.	4.	4.	5.	10.	5.	7.	6.	5.	1.
88	10.	4.	6.	6.	10.	4.	10.	6.	5.	1.
84	7.	5.	10.	7.	10.	2.	11.	7.	6.	1.
80	12.	6.	17.	9.	10.	2.	8.	9.	6.	2.

ZONAL WIND

ATLANTA (34N,84W) SEP 1 - SEP 30, 1982



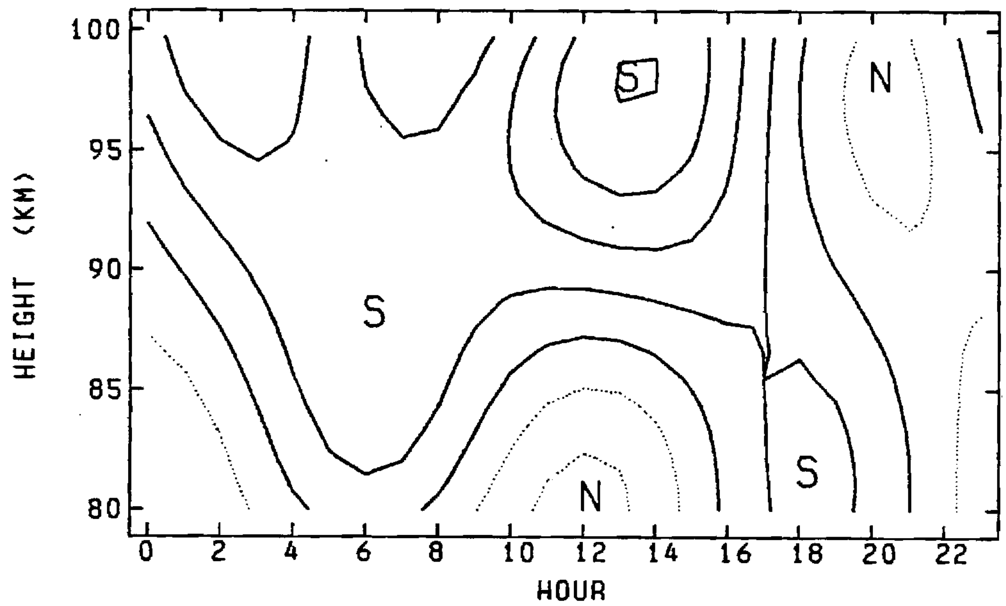
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

SEP 1 - SEP 30 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	3.	5.	3.	8.	21.	9.	14.	7.	2.	1.
96	-1.	5.	11.	8.	13.	2.	3.	7.	9.	4.
92	-3.	4.	10.	6.	11.	2.	12.	6.	8.	1.
88	-6.	5.	8.	6.	7.	3.	15.	7.	8.	1.
84	-8.	6.	12.	8.	4.	3.	14.	8.	8.	1.
80	-12.	6.	9.	10.	3.	4.	14.	9.	8.	1.

MERIDIONAL WIND

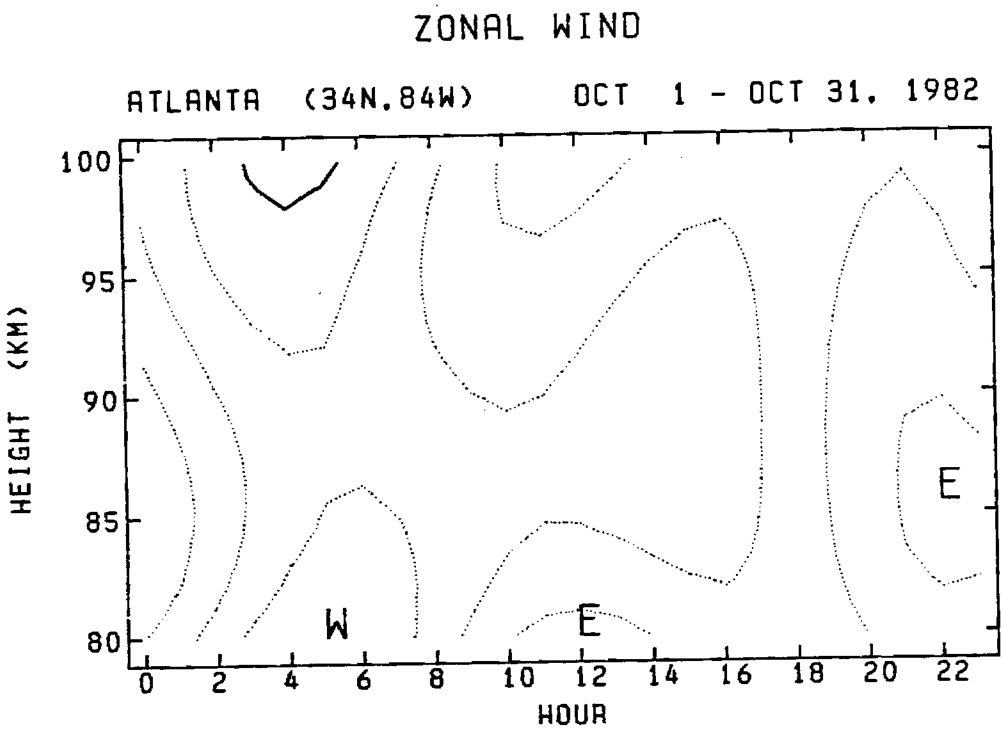
ATLANTA (34N,84W) SEP 1 - SEP 30, 1982



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

SEP 1 - SEP 30 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	24.	5.	6.	7.	10.	5.	19.	7.	2.	1.
96	24.	4.	14.	6.	10.	2.	16.	6.	2.	1.
92	21.	4.	13.	5.	10.	2.	8.	5.	3.	1.
88	15.	4.	8.	6.	9.	3.	9.	6.	5.	1.
84	8.	5.	1.	7.	4.	24.	15.	7.	6.	1.
80	2.	5.	7.	7.	20.	5.	14.	8.	6.	1.



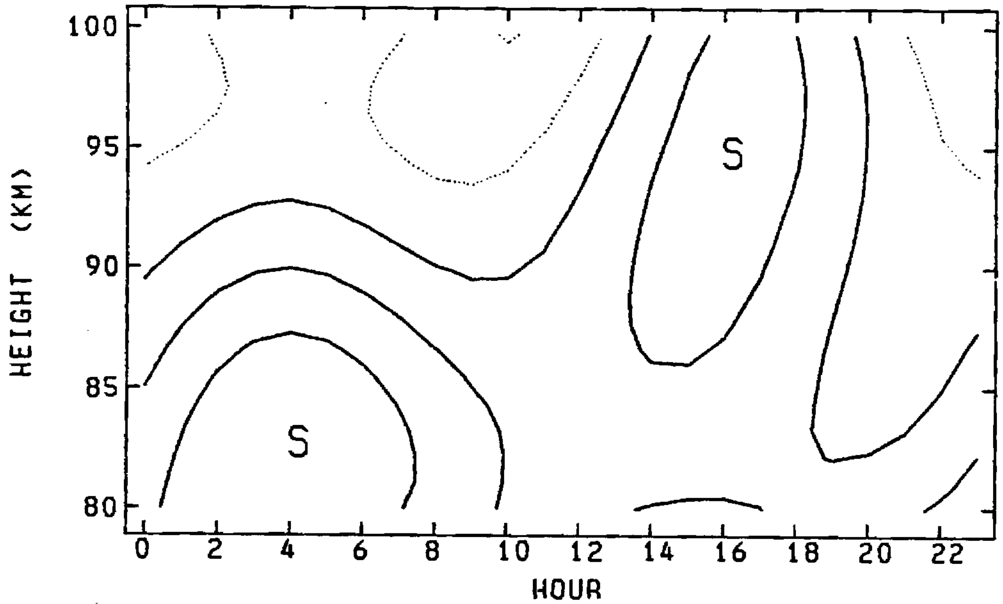
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

OCT 1 - OCT 31 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-10.	5.	15.	8.	4.	2.	11.	8.	5.	1.
96	-10.	5.	8.	7.	4.	3.	10.	7.	4.	1.
92	-12.	4.	7.	5.	8.	3.	9.	6.	4.	1.
88	-13.	5.	12.	6.	10.	2.	8.	6.	4.	2.
84	-13.	5.	12.	7.	9.	2.	9.	7.	5.	1.
80	-12.	6.	13.	9.	4.	3.	13.	9.	5.	1.

MERIDIONAL WIND

ATLANTA (34N,84W) OCT 1 - OCT 31, 1982



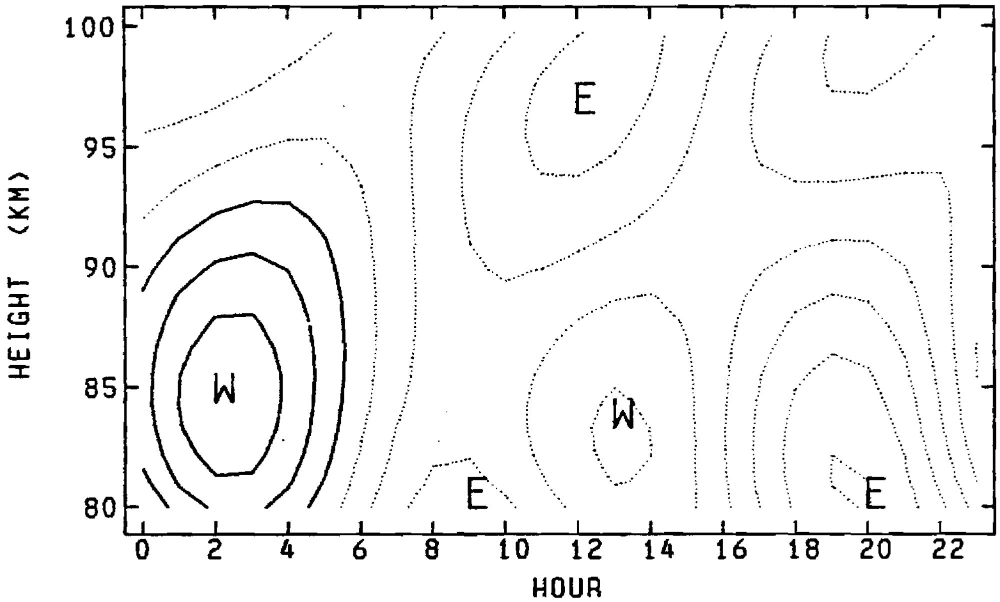
NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

OCT 1 - OCT 31 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	4.	5.	4.	6.	18.	6.	14.	7.	5.	1.
96	5.	4.	11.	6.	17.	2.	8.	6.	4.	1.
92	11.	4.	6.	6.	15.	3.	7.	5.	4.	1.
88	17.	4.	6.	5.	7.	4.	8.	6.	3.	1.
84	22.	5.	13.	6.	5.	2.	6.	6.	4.	2.
80	21.	5.	13.	8.	3.	2.	1.	7.	8.	11.

ZONAL WIND

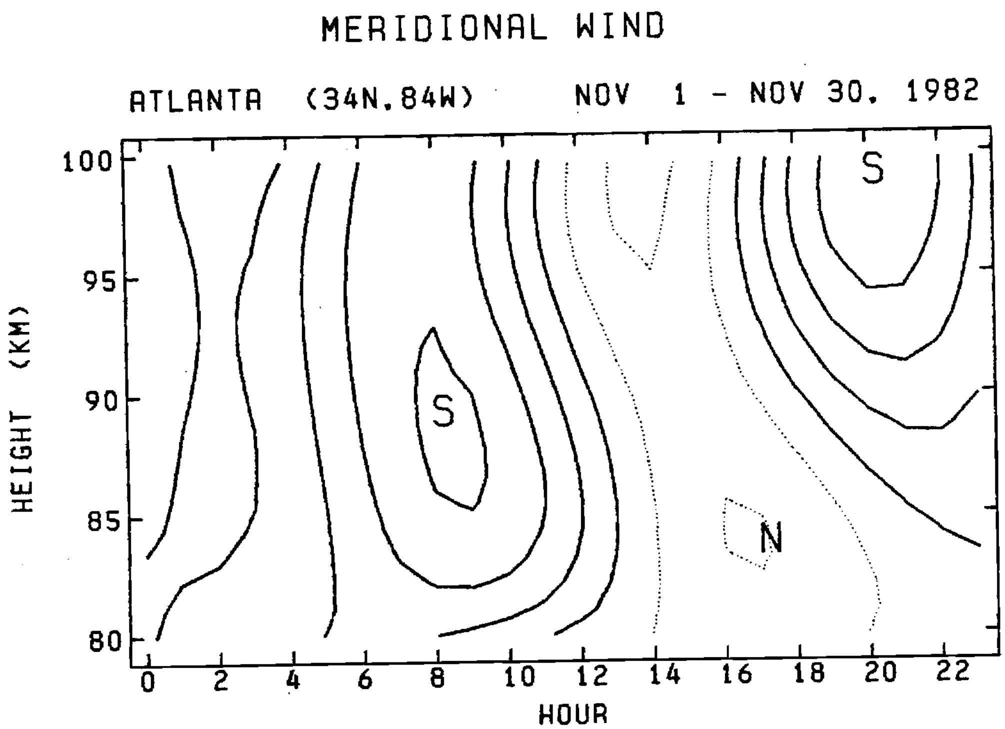
ATLANTA (34N,84W) NOV 1 - NOV 30, 1982



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

NOV 1 - NOV 30 1982

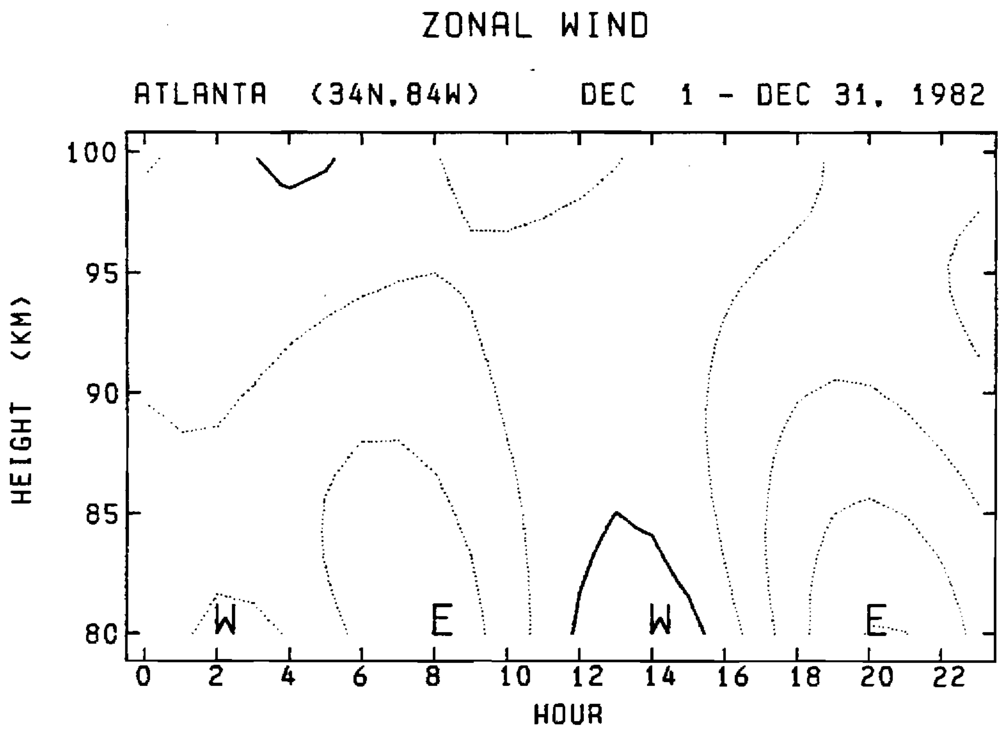
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-12.	6.	9.	9.	24.	3.	11.	9.	8.	1.
96	-13.	6.	11.	9.	24.	3.	10.	8.	6.	2.
92	-10.	5.	15.	8.	2.	2.	9.	7.	4.	1.
88	-6.	5.	21.	8.	4.	1.	18.	7.	2.	1.
84	-7.	6.	24.	8.	5.	1.	25.	8.	2.	1.
80	-18.	8.	14.	11.	5.	3.	22.	11.	2.	1.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

NOV 1 - NOV 30 1982

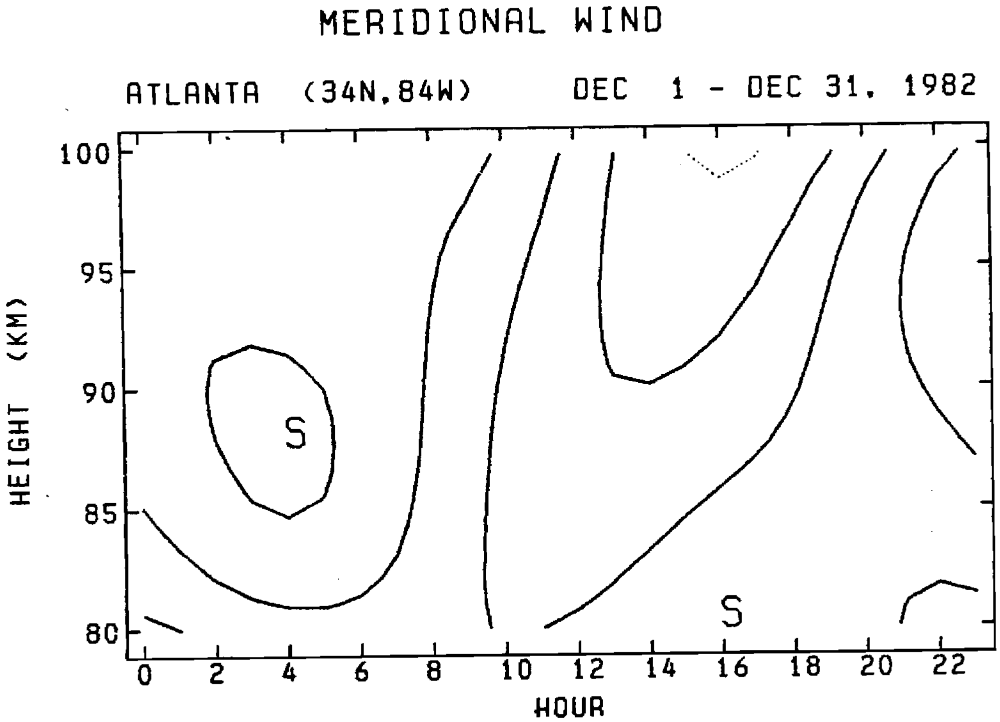
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	18.	5.	9.	8.	24.	3.	24.	8.	8.	1.
96	20.	5.	10.	8.	0.	2.	22.	7.	8.	1.
92	19.	4.	9.	7.	4.	3.	18.	6.	8.	1.
88	15.	5.	15.	6.	7.	2.	14.	7.	9.	1.
84	11.	5.	17.	7.	7.	2.	9.	7.	10.	1.
80	8.	6.	10.	9.	4.	3.	3.	8.	5.	5.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

DEC 1 - DEC 31 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	0.	6.	3.	8.	5.	9.	9.	7.	4.	2.
96	2.	5.	2.	7.	5.	11.	3.	7.	3.	4.
92	0.	4.	2.	5.	9.	11.	5.	6.	1.	2.
88	-5.	5.	5.	6.	11.	5.	8.	6.	1.	1.
84	-7.	5.	8.	8.	11.	3.	12.	7.	2.	1.
80	-6.	7.	11.	9.	11.	3.	19.	9.	2.	1.



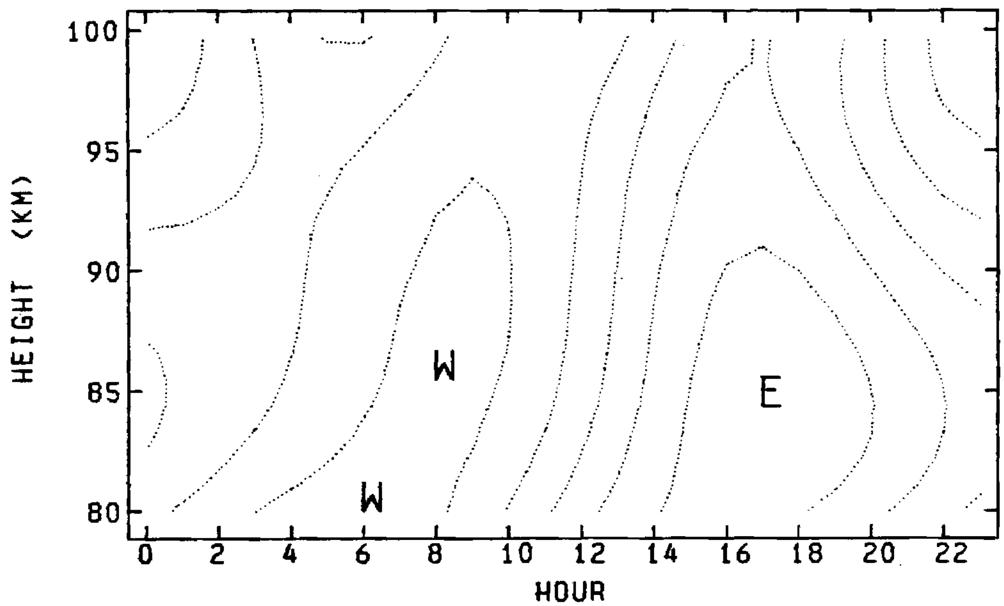
NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

DEC 1 - DEC 31 1982

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	21.	5.	18.	7.	5.	1.	7.	7.	10.	2.
96	24.	5.	16.	7.	3.	1.	5.	6.	10.	2.
92	26.	4.	16.	6.	2.	1.	2.	6.	8.	5.
88	26.	4.	13.	7.	3.	1.	4.	6.	5.	3.
84	25.	5.	7.	7.	3.	3.	6.	6.	5.	2.
80	22.	6.	6.	9.	15.	5.	4.	8.	5.	5.

ZONAL WIND

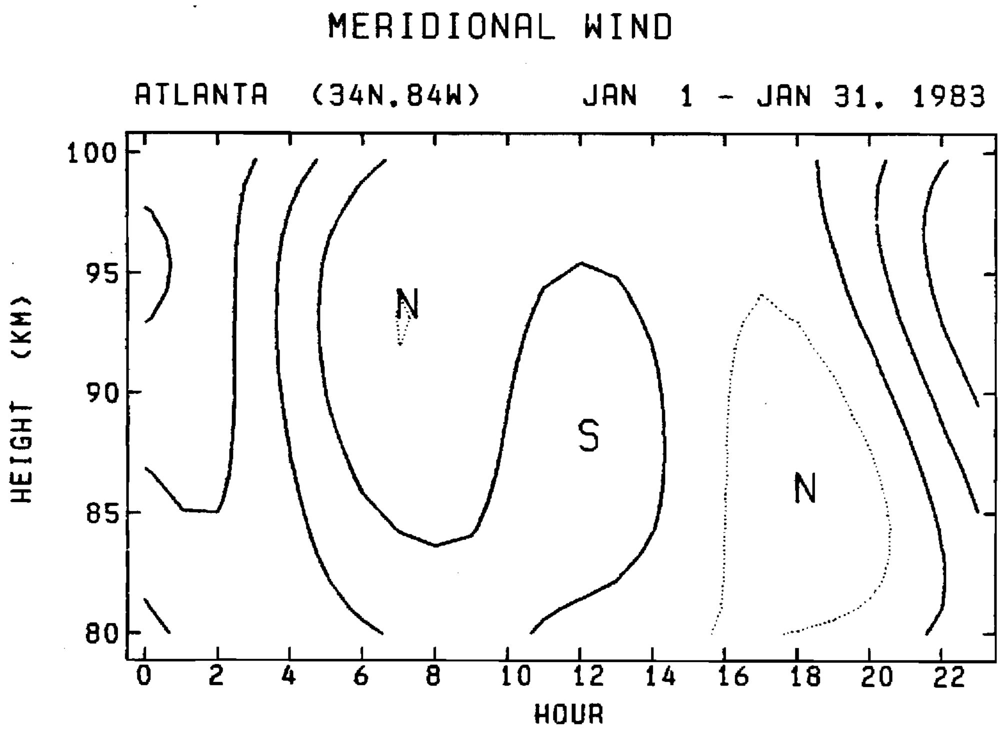
ATLANTA (34N,84W) JAN 1 - JAN 31, 1983



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

JAN 1 - JAN 31 1983

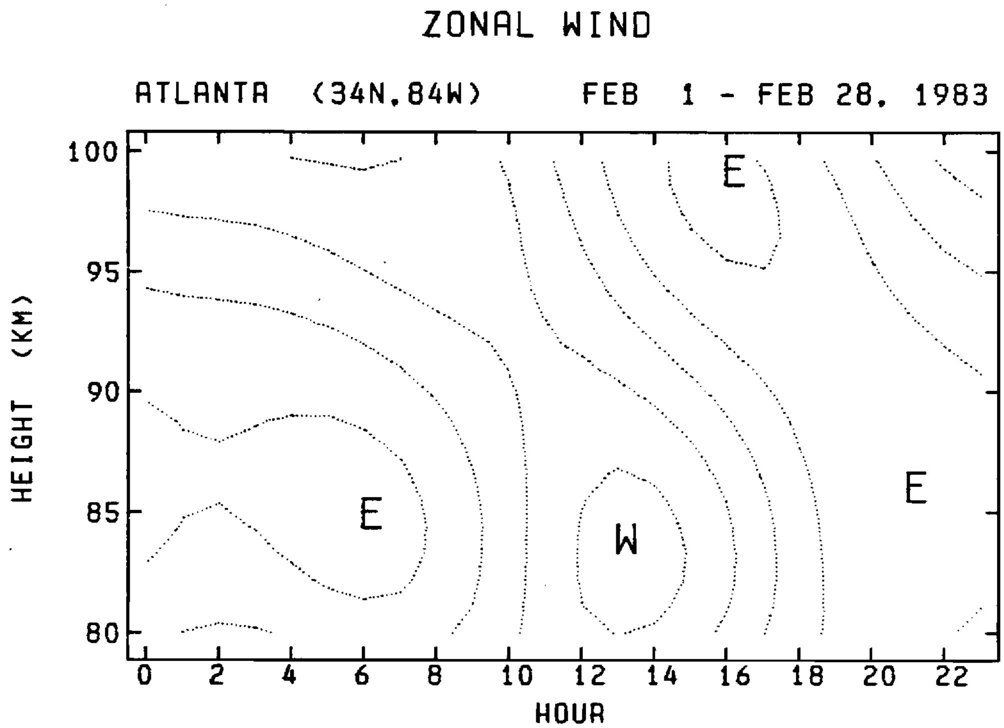
HEIGHT	MEAN	ERROR	24 HOUR AMP	ERROR	PHI	ERROR	12 HOUR AMP	ERROR	PHI	ERROR
100	-11.	6.	5.	10.	2.	7.	17.	9.	11.	1.
96	-12.	6.	10.	9.	4.	3.	11.	8.	11.	1.
92	-15.	5.	15.	7.	6.	2.	9.	6.	10.	2.
88	-20.	5.	21.	7.	7.	1.	7.	7.	10.	2.
84	-21.	6.	24.	8.	6.	1.	5.	8.	10.	4.
80	-17.	7.	25.	10.	4.	2.	4.	10.	7.	5.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JAN 1 - JAN 31 1983

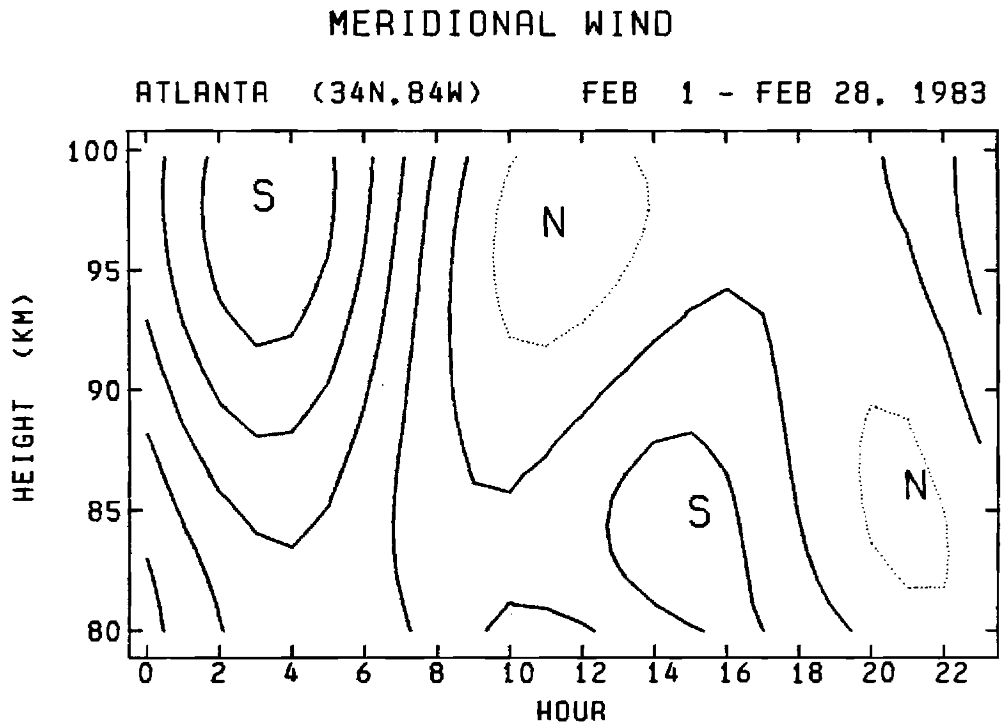
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	15.	6.	17.	9.	1.	2.	4.	8.	2.	4.
96	15.	5.	16.	8.	24.	2.	10.	7.	0.	1.
92	14.	4.	13.	6.	1.	2.	13.	6.	0.	1.
88	12.	5.	10.	7.	3.	2.	13.	7.	1.	1.
84	11.	5.	12.	8.	4.	3.	8.	8.	1.	2.
80	12.	6.	12.	8.	4.	3.	3.	9.	8.	6.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

FEB 1 - FEB 28 1983

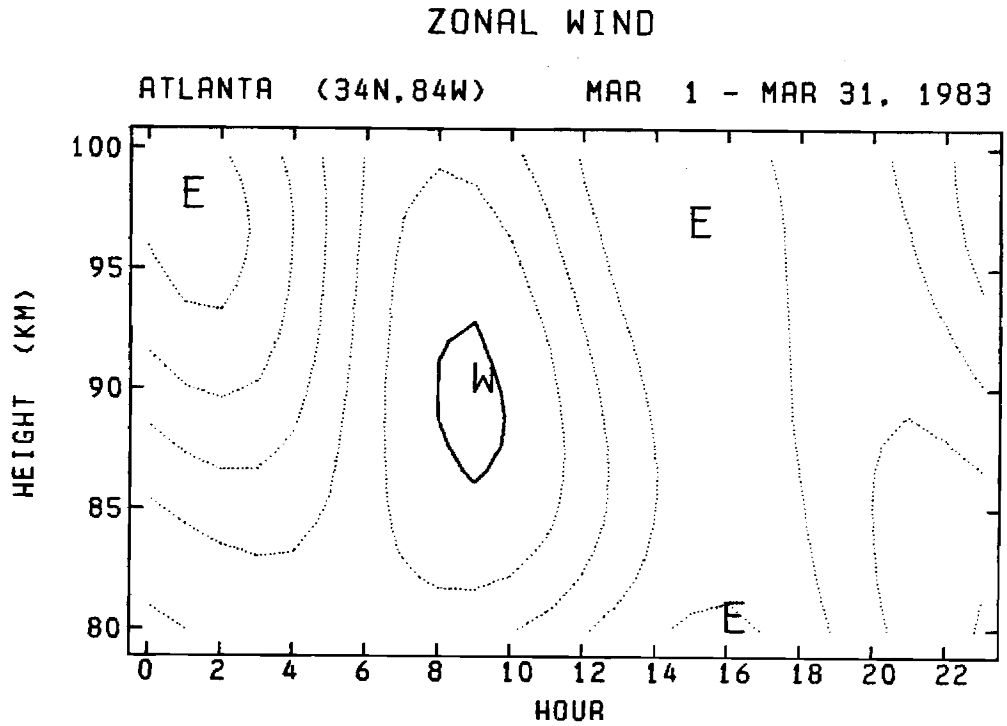
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-14.	6.	22.	10.	3.	1.	5.	9.	9.	4.
96	-20.	6.	17.	8.	5.	2.	6.	8.	10.	2.
92	-23.	5.	11.	6.	9.	3.	5.	7.	11.	3.
88	-24.	5.	15.	8.	12.	2.	8.	7.	1.	2.
84	-22.	6.	16.	9.	13.	2.	11.	8.	2.	1.
80	-18.	7.	9.	9.	10.	5.	8.	10.	1.	2.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

FEB 1 - FEB 28 1983

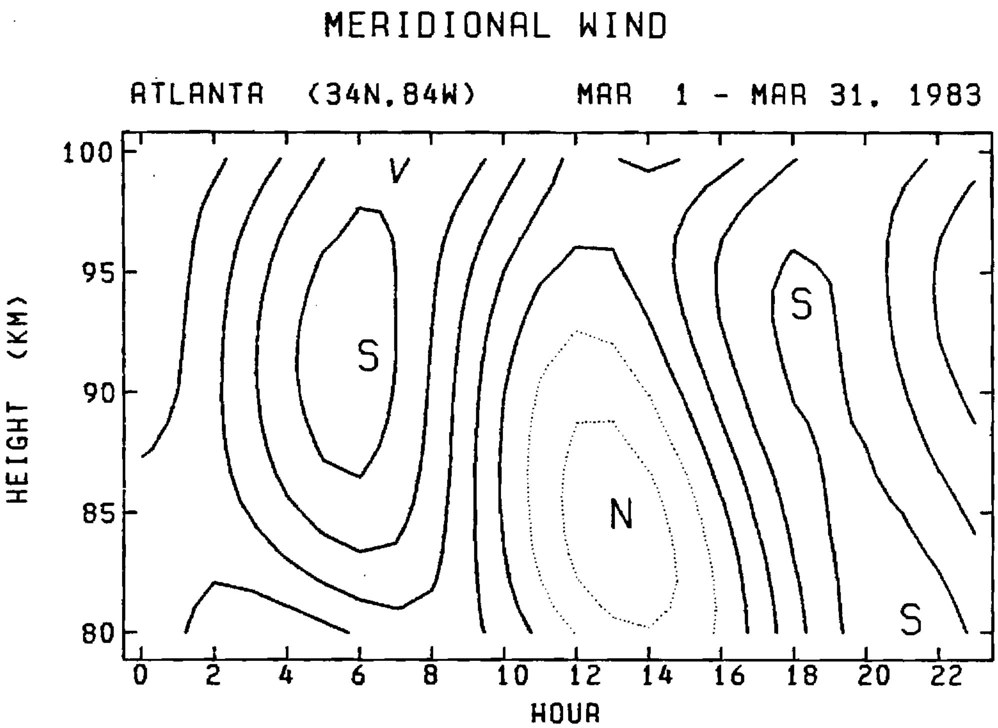
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	21.	6.	24.	9.	3.	1.	11.	8.	4.	1.
96	19.	5.	26.	8.	3.	1.	13.	7.	4.	1.
92	18.	4.	19.	6.	3.	1.	14.	6.	3.	1.
88	17.	4.	10.	6.	5.	2.	13.	6.	3.	1.
84	16.	5.	7.	7.	8.	4.	11.	7.	3.	1.
80	14.	6.	5.	9.	4.	7.	11.	9.	5.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

MAR 1 - MAR 31 1983

HEIGHT	MEAN	ERROR	24 HOUR AMP	ERROR	PHI	ERROR	12 HOUR AMP	ERROR	PHI	ERROR
100	-22.	8.	9.	11.	10.	5.	11.	11.	7.	2.
96	-21.	7.	13.	9.	10.	3.	15.	9.	8.	1.
92	-16.	6.	13.	8.	10.	2.	15.	8.	8.	1.
88	-11.	7.	10.	8.	9.	4.	13.	9.	9.	1.
84	-9.	7.	9.	10.	5.	5.	10.	10.	10.	2.
80	-14.	10.	17.	15.	3.	3.	5.	12.	10.	5.



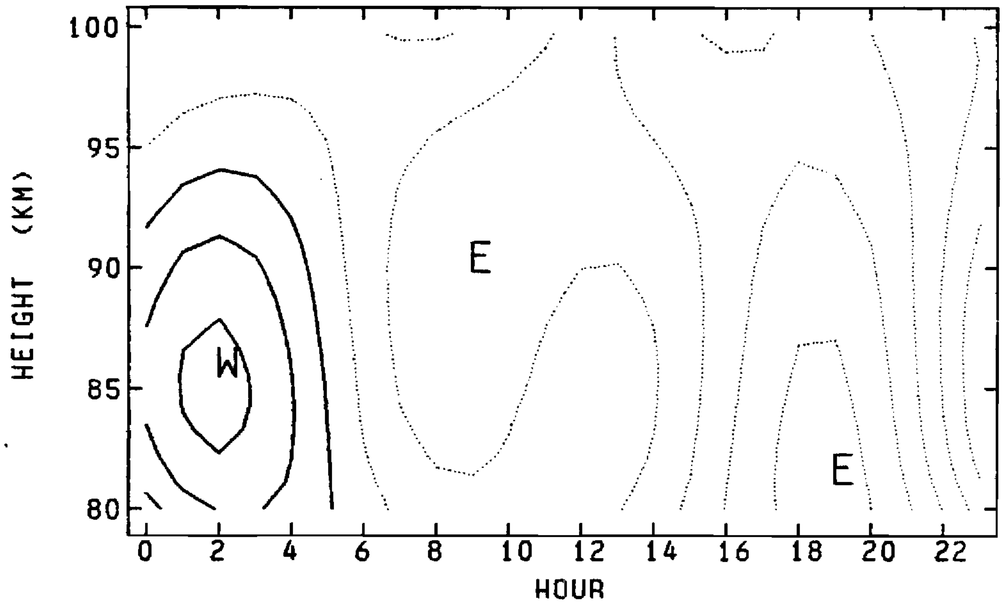
NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

MAR 1 - MAR 31 1983

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	27.	7.	10.	10.	5.	4.	18.	9.	8.	1.
96	29.	7.	6.	9.	5.	6.	17.	9.	6.	1.
92	28.	6.	10.	9.	3.	3.	21.	8.	6.	1.
88	24.	6.	17.	9.	2.	2.	21.	9.	6.	1.
84	21.	7.	20.	10.	1.	2.	18.	9.	7.	1.
80	19.	8.	14.	11.	22.	3.	17.	11.	9.	1.

ZONAL WIND

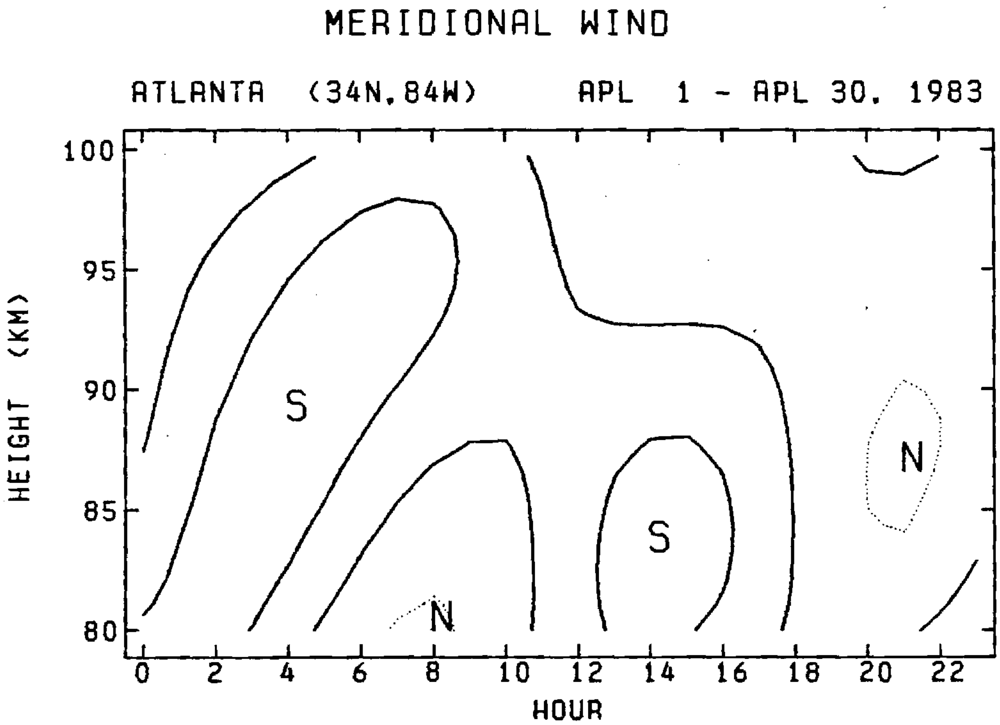
ATLANTA (34N,84W) APL 1 - APL 30, 1983



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

APL 1 - APL 30 1983

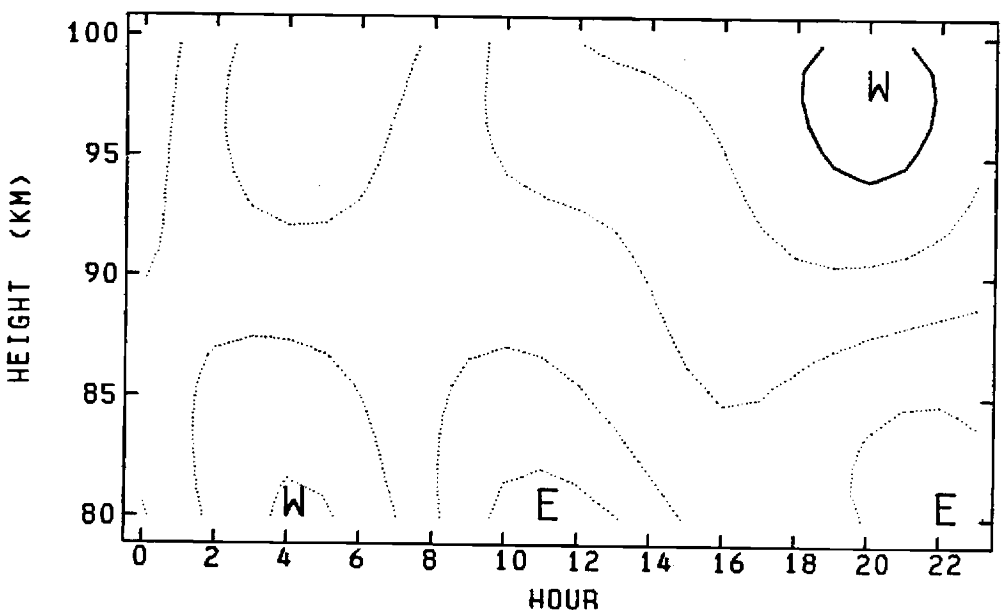
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-12.	5.	15.	7.	5.	2.	7.	7.	10.	2.
96	-13.	5.	14.	7.	4.	2.	4.	7.	1.	4.
92	-10.	4.	18.	6.	3.	1.	12.	6.	1.	1.
88	-8.	4.	22.	6.	3.	1.	19.	6.	1.	1.
84	-7.	5.	24.	7.	4.	1.	19.	7.	1.	1.
80	-12.	6.	24.	9.	5.	1.	10.	9.	2.	2.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

APL 1 - APL 30 1983

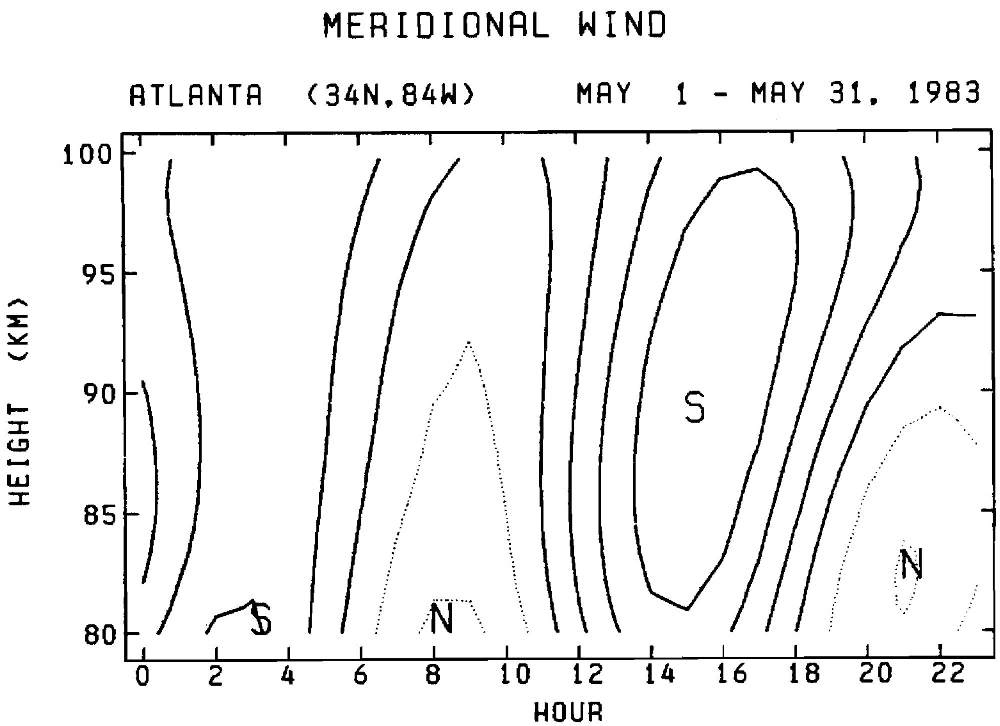
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	7.	5.	1.	7.	3.	18.	5.	6.	9.	3.
96	10.	4.	8.	6.	6.	3.	5.	6.	7.	2.
92	12.	4.	9.	5.	7.	2.	5.	5.	5.	2.
88	13.	4.	6.	5.	8.	4.	9.	5.	3.	1.
84	13.	4.	1.	6.	11.	22.	12.	6.	2.	1.
80	12.	5.	5.	7.	21.	6.	10.	7.	1.	1.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

MAY 1 - MAY 31 1983

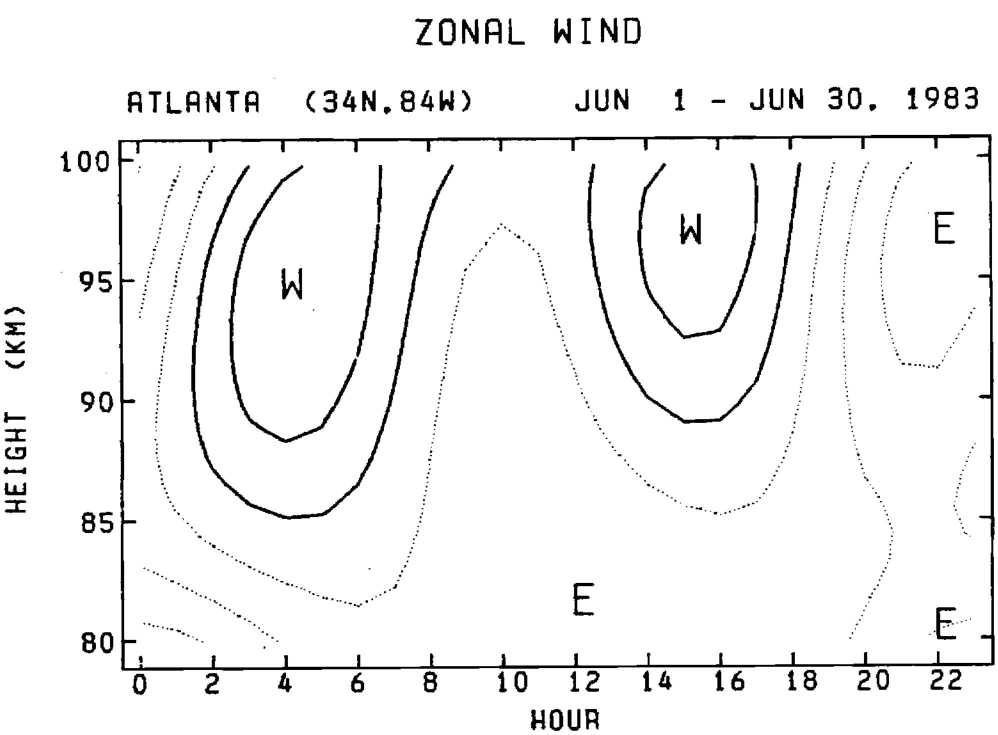
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-5.	6.	18.	8.	17.	2.	5.	9.	11.	3.
96	-6.	6.	16.	7.	18.	2.	7.	7.	9.	2.
92	-9.	5.	11.	6.	19.	3.	4.	6.	9.	3.
88	-12.	5.	4.	7.	20.	7.	3.	7.	4.	4.
84	-16.	6.	5.	8.	3.	6.	9.	8.	4.	2.
80	-18.	8.	10.	11.	2.	4.	13.	10.	5.	1.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

MAY 1 - MAY 31 1983

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	22.	5.	5.	7.	19.	6.	9.	7.	5.	1.
96	23.	5.	11.	6.	18.	2.	13.	6.	4.	1.
92	21.	4.	11.	5.	17.	2.	17.	5.	4.	1.
88	18.	4.	11.	5.	15.	2.	20.	5.	3.	1.
84	14.	4.	8.	6.	14.	3.	23.	6.	3.	1.
80	11.	6.	4.	8.	21.	7.	23.	8.	2.	1.



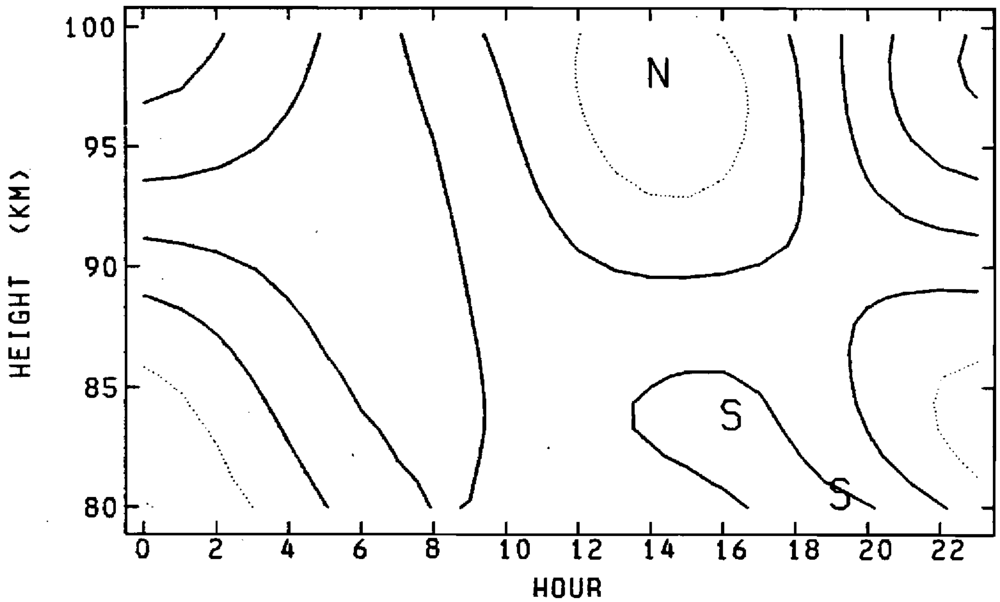
EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

JUN 1 - JUN 30 1983

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	5.	7.	14.	10.	11.	2.	14.	9.	5.	1.
96	6.	6.	13.	8.	10.	3.	20.	8.	4.	1.
92	5.	5.	9.	6.	8.	3.	18.	6.	4.	1.
88	1.	6.	7.	7.	6.	5.	11.	7.	4.	1.
84	-5.	6.	4.	8.	6.	10.	6.	9.	5.	3.
80	-12.	8.	12.	13.	12.	3.	9.	11.	6.	2.

MERIDIONAL WIND

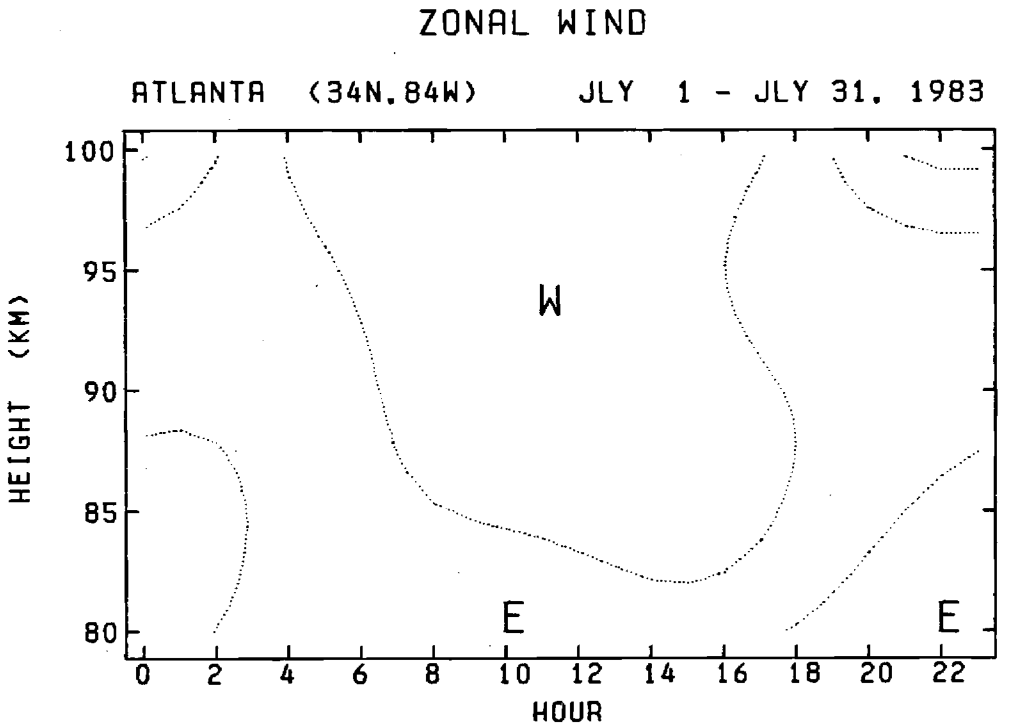
ATLANTA (34N,84W) JUN 1 - JUN 30, 1983



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JUN 1 - JUN 30 1983

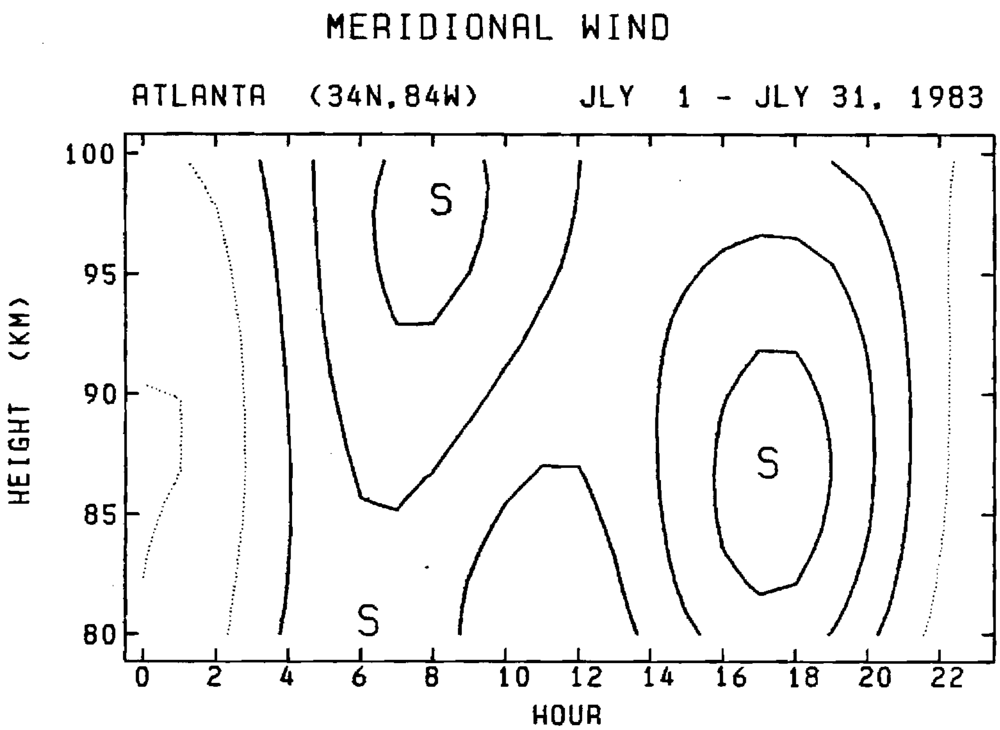
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	20.	5.	21.	8.	1.	1.	1.	8.	0.	10.
96	18.	5.	21.	8.	2.	1.	5.	7.	10.	3.
92	16.	4.	11.	6.	3.	2.	3.	6.	8.	4.
88	14.	5.	7.	6.	9.	4.	4.	6.	6.	3.
84	13.	5.	11.	8.	12.	2.	6.	7.	6.	2.
80	13.	6.	6.	8.	17.	6.	11.	9.	8.	2.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

JLY 1 - JLY 31 1983

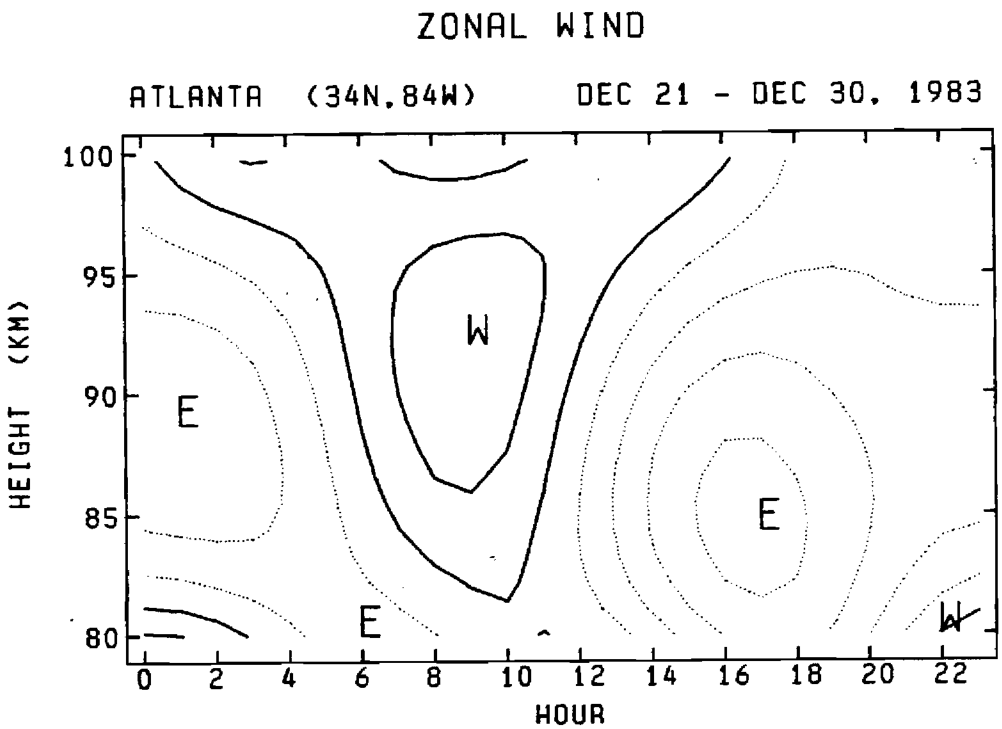
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	-5.	5.	16.	7.	11.	2.	9.	7.	5.	1.
96	-1.	5.	8.	7.	11.	3.	0.	6.	5.	29.
92	0.	4.	7.	6.	12.	3.	2.	5.	10.	6.
88	-2.	4.	8.	6.	12.	3.	1.	6.	7.	11.
84	-6.	5.	6.	7.	12.	3.	3.	6.	5.	4.
80	-11.	5.	5.	7.	6.	6.	5.	7.	3.	3.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

JLY 1 - JLY 31 1983

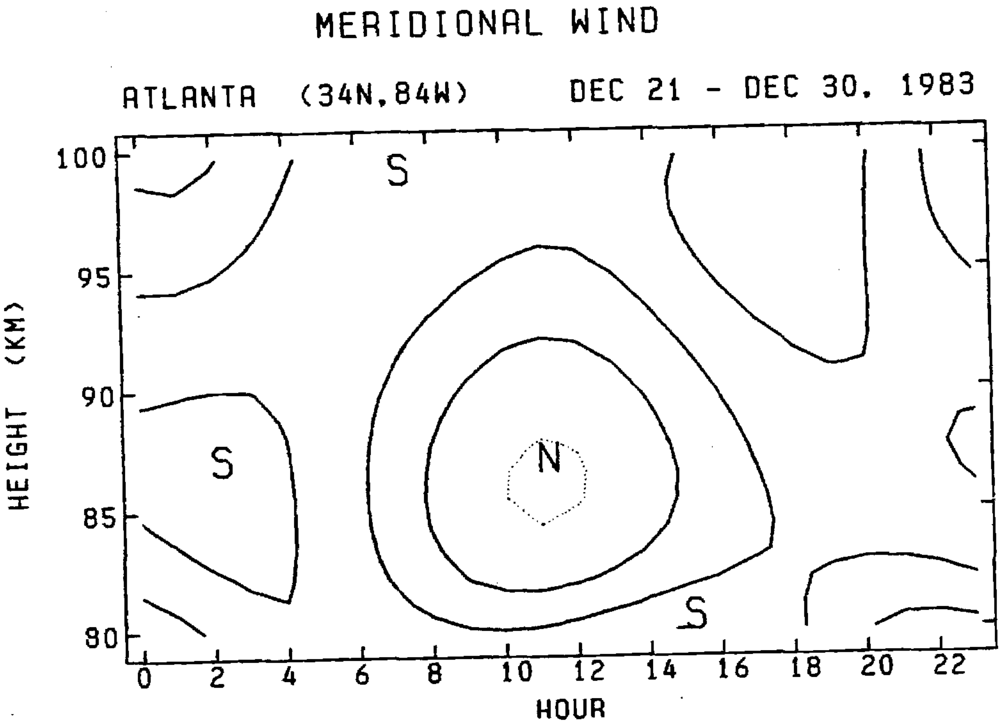
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	14.	4.	14.	6.	9.	2.	5.	6.	7.	2.
96	15.	4.	13.	5.	11.	1.	10.	5.	7.	1.
92	15.	3.	13.	4.	13.	1.	13.	4.	6.	1.
88	14.	3.	12.	5.	14.	1.	14.	5.	6.	1.
84	12.	4.	11.	5.	15.	2.	14.	5.	6.	1.
80	8.	4.	6.	6.	13.	4.	12.	6.	6.	1.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

DEC 21 - DEC 30 1983

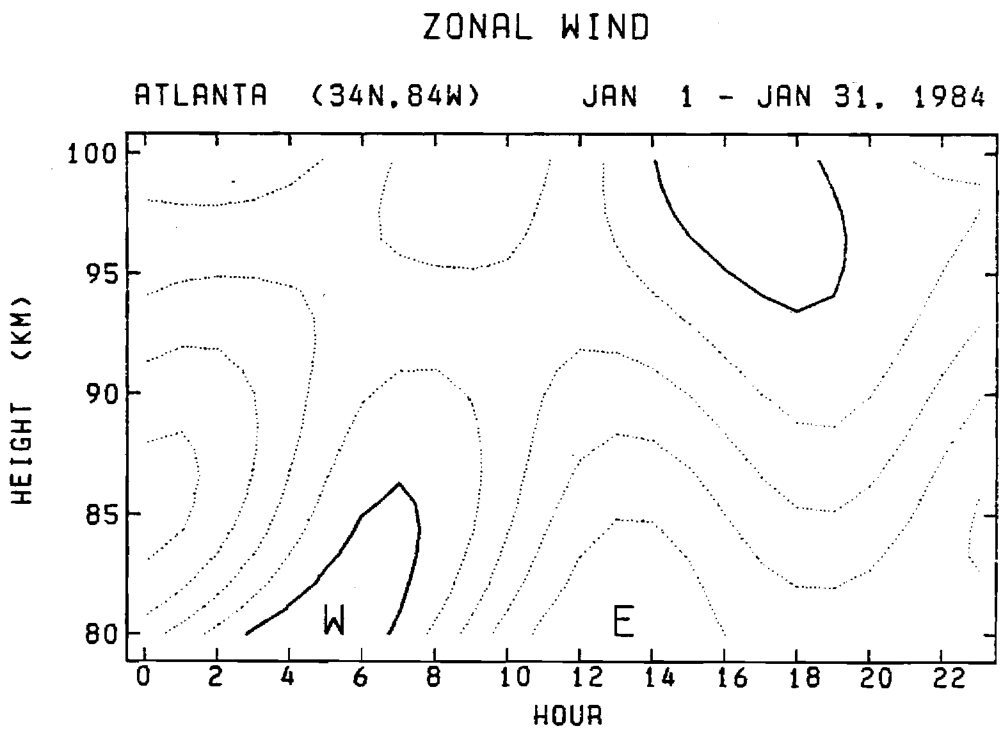
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	8.	10.	6.	12.	7.	9.	14.	13.	3.	2.
96	6.	9.	14.	11.	9.	4.	2.	12.	12.	12.
92	-2.	8.	20.	9.	9.	2.	9.	10.	9.	2.
88	-9.	8.	21.	9.	8.	2.	12.	10.	9.	2.
84	-9.	8.	16.	11.	7.	3.	11.	11.	10.	2.
80	5.	10.	12.	15.	2.	4.	19.	15.	0.	1.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

DEC 21 - DEC 30 1983

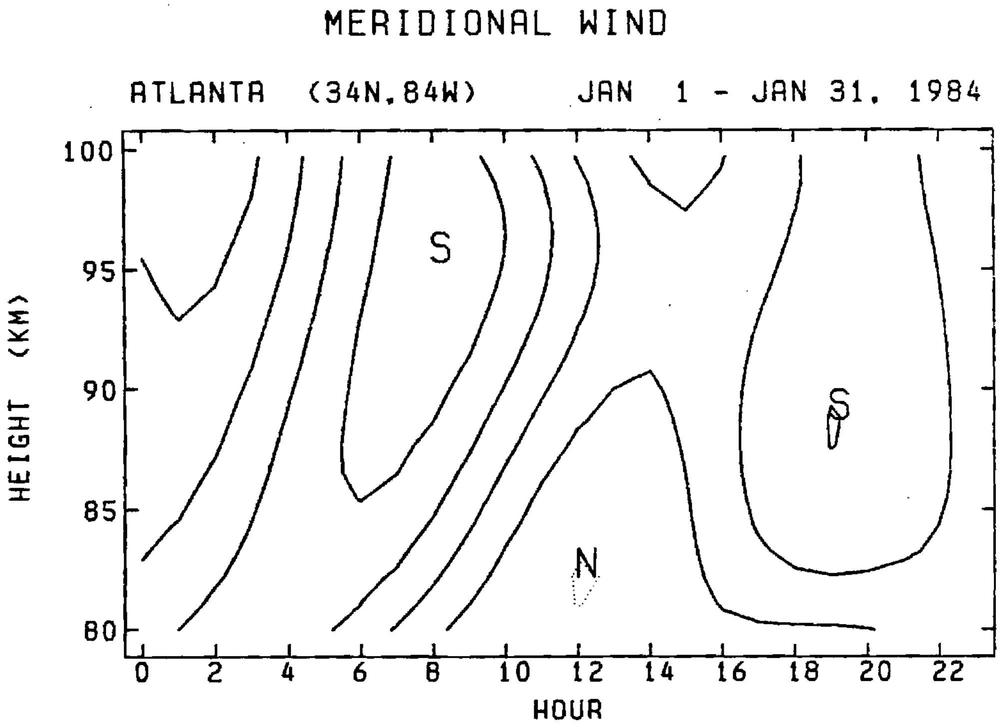
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	23.	8.	9.	11.	15.	5.	9.	12.	7.	2.
96	25.	8.	6.	11.	15.	8.	7.	11.	6.	3.
92	23.	7.	8.	9.	23.	4.	5.	9.	5.	3.
88	19.	7.	16.	10.	24.	2.	4.	9.	5.	4.
84	19.	7.	12.	11.	0.	3.	6.	10.	4.	4.
80	23.	9.	16.	13.	11.	3.	9.	12.	4.	3.



EAST-WEST WIND COMPONENTS, ATLANTA (34N,84W)

JAN 1 - JAN 31 1984

			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	1.	6.	8.	8.	19.	5.	12.	8.	4.	1.
96	-1.	6.	11.	7.	18.	3.	4.	8.	4.	4.
92	-6.	5.	7.	7.	16.	4.	8.	7.	7.	1.
88	-12.	5.	7.	7.	10.	4.	15.	7.	7.	1.
84	-16.	6.	15.	8.	6.	2.	15.	9.	6.	1.
80	-15.	7.	28.	10.	3.	1.	12.	10.	4.	2.



NORTH-SOUTH WIND COMPONENTS, ATLANTA (34N,84W)

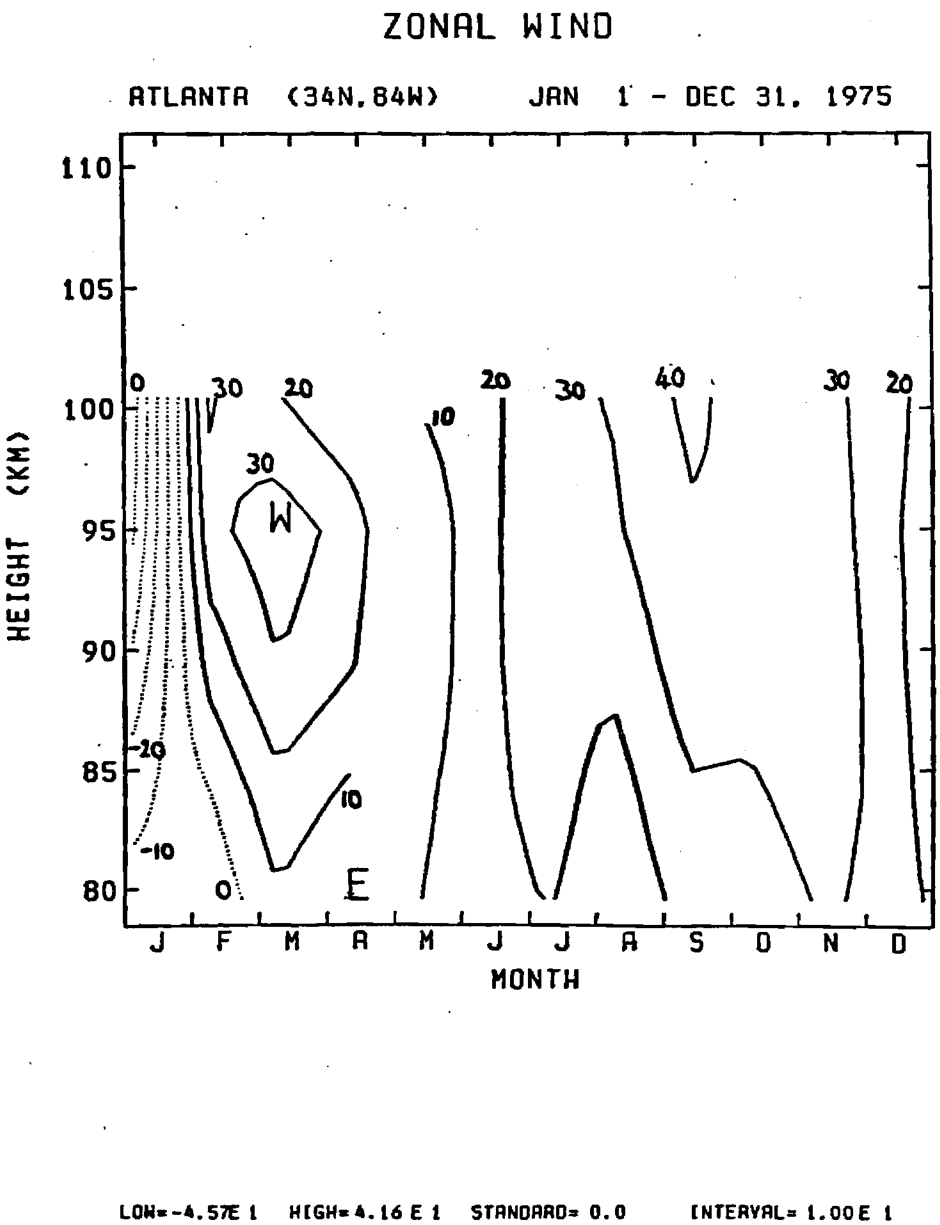
JAN 1 - JAN 31 1984

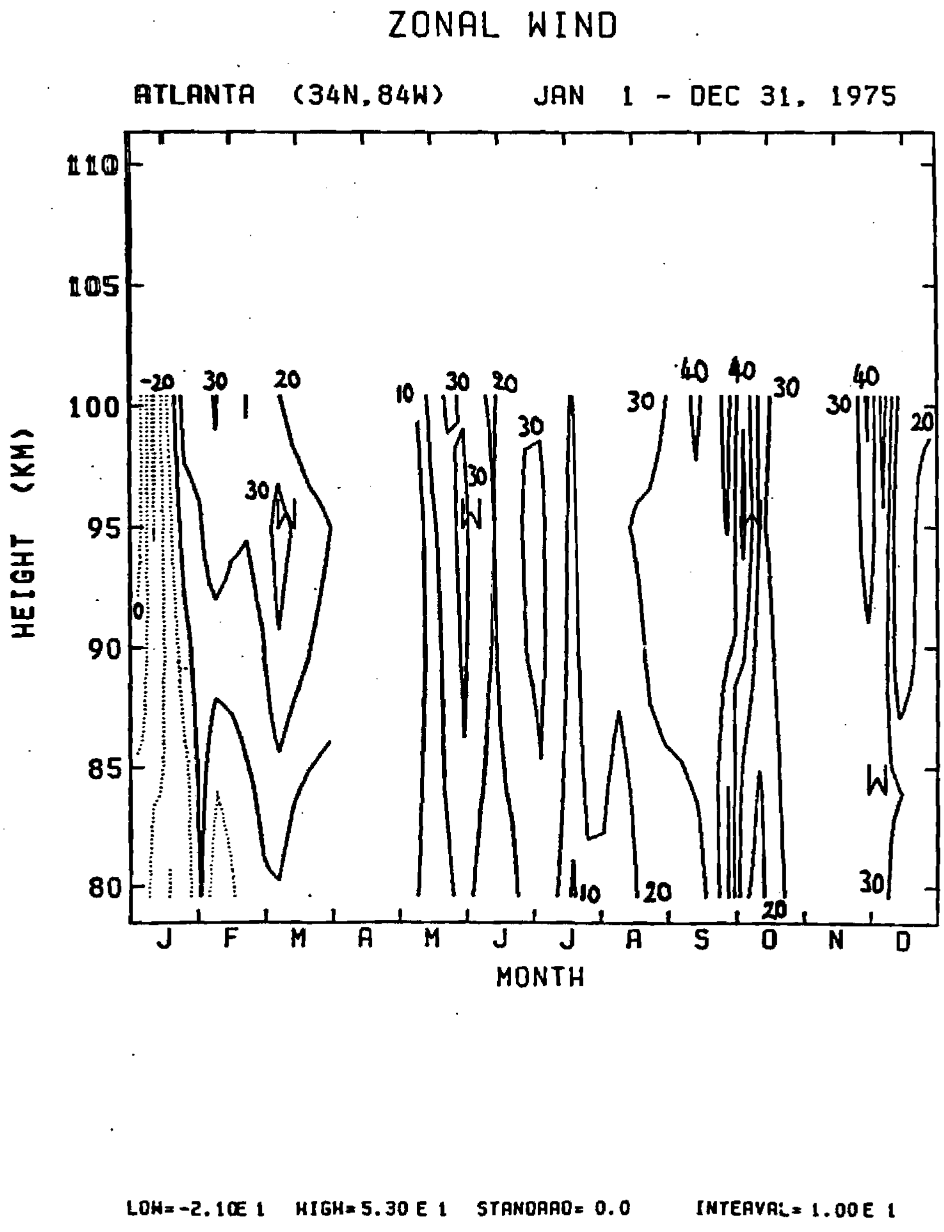
			24 HOUR				12 HOUR			
HEIGHT	MEAN	ERROR	AMP	ERROR	PHI	ERROR	AMP	ERROR	PHI	ERROR
100	19.	5.	9.	7.	8.	3.	15.	8.	8.	1.
96	23.	5.	11.	7.	9.	3.	13.	7.	8.	1.
92	24.	4.	8.	6.	8.	3.	13.	6.	8.	1.
88	23.	5.	8.	6.	4.	4.	13.	7.	7.	1.
84	20.	6.	12.	8.	2.	2.	10.	7.	6.	1.
80	13.	6.	15.	9.	2.	2.	8.	9.	3.	2.

CHAPTER III

The following are plots of the mean zonal and meridional circulation variation with height and time for the year 1975 (the results for the winter of 1974-75 have been discussed in detail by Dolas and Roper (1981)). The first plot of each pair is constructed from a data set which uses only the middle week of each month - a common "modus operandi" for those stations unable to operate continuously. The second plot of each pair is constructed from the total data set (weekly means) measured by the Georgia Tech Radio Meteor Wind Facility. Note that in both sets some six weeks of data is missing due to equipment failure in April/May.

Comparisons between these plots show conclusively the significance of the synoptic scale disturbances present at these altitudes, and that caution should be exercised in using non-continuous data sets in evaluating the dynamic energetics of this region.


ZONAL WIND
ATLANTA (34N, 84W) JAN 1 - DEC 31, 1975
HEIGHT (KM)
110
105
100
95
90
85
80
J F M A M J J A S O N D
MONTH
W
E
0
30
20
10
-20
-10
40
LOW=-4.57E 1 HIGH=4.16 E 1 STANDARD= 0.0 INTERVAL= 1.00 E 1


ZONAL WIND
ATLANTA (34N,84W) JAN 1 - DEC 31, 1975
HEIGHT (KM)
110
105
100
95
90
85
80
J F M A M J J A S O N D
MONTH
-20
30
20
10
40
W
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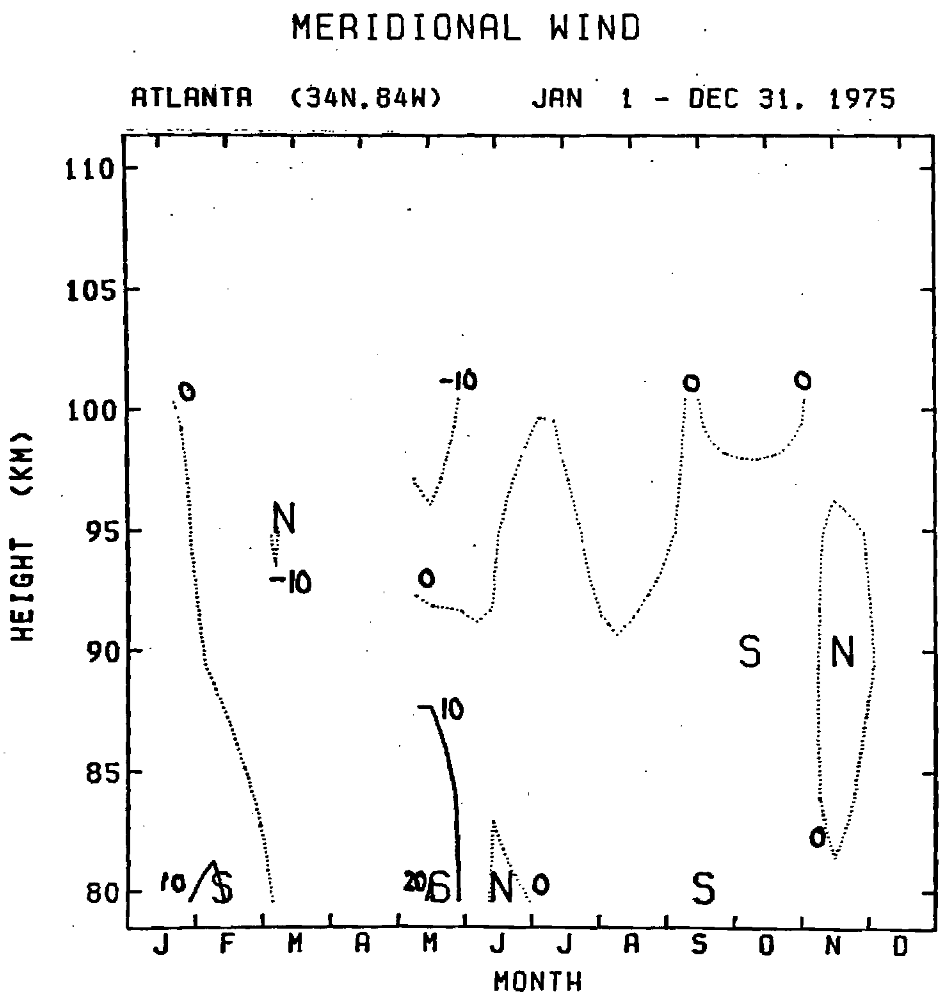
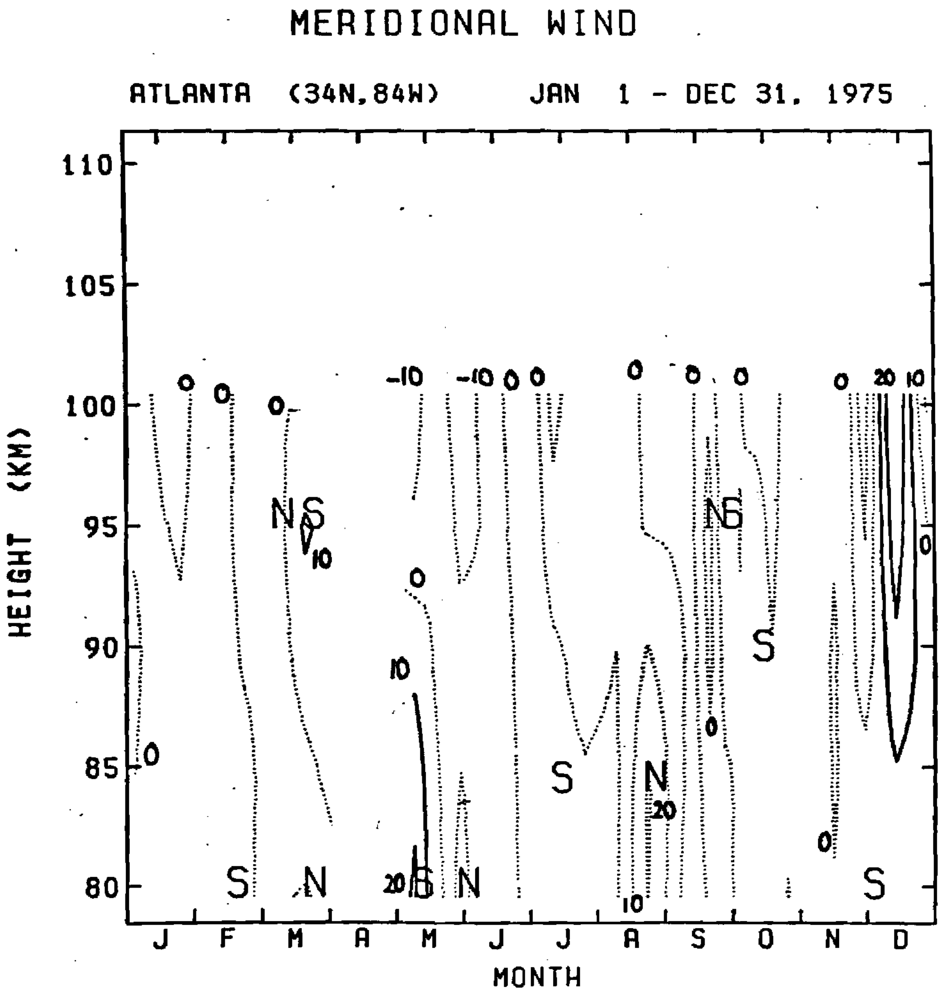


LOW=-1.73E 1 HIGH=2.06 E 1 STANDARD= 0.0 INTERVAL= 1.00 E 1

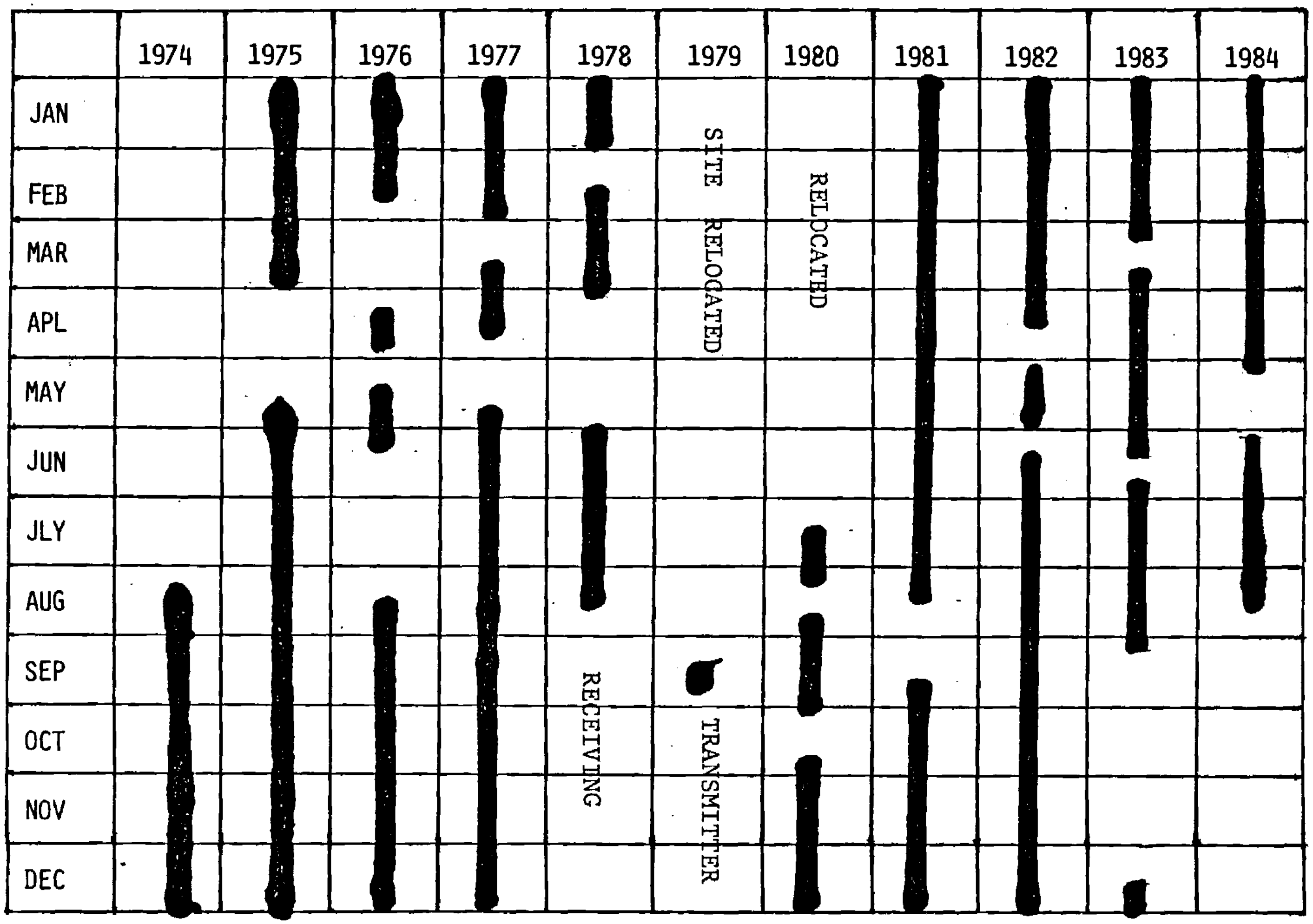


LOW= -2.14E 1 HIGH= 3.28 E 1 STANDARD= 0.0 INTERVAL= 1.00 E 1

APPENDIX I

The Operating Schedule of the
Georgia Tech Radio Meteor Wind Facility
August 1974 - August 1984

OPERATING SCHEDULE OF THE GEORGIA TECH RADIO METEOR WIND FACILITY



GAP denotes an interval in excess of two weeks

APPENDIX II

"Mean Winds of the Upper Middle Atmosphere (60-110 km):
A Global Distribution from Radar Systems
(M.F., Metoer, VHF)", by Manson et al. (1984).
To be published in the MAP Handbook.

MEAN WINDS OF THE UPPER MIDDLE ATMOSPHERE (60-110 km): A GLOBAL DISTRIBUTION FROM RADAR SYSTEMS (M.F., METEOR, VHF)

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ABSTRACT

During the last decade a large number of radars (~12) have been developed, which have produced substantial quantities of tidally-corrected mean winds data in the upper Middle Atmosphere. The distribution of the radars is not global, but many areas are well covered: the Americas with Poker Flat (65°N), Saskatoon (52°N), Durham (43°N), Atlanta (35°N), Puerto Rico (18°N); Europe with Kiruna (68°), Garchy (47°N) and Monpazier (44°N); and Oceania with Christchurch (44°S), Adelaide (35°S), Townsville (20°S), and Kyoto (35°N).

Zonal and meridional wind height-time cross-sections from 60/80 km (MF/Meteor Radar) to ~110 km have been prepared for the last 5-6 years. They are compared with cross-sections from CIRA-72 for zonal winds, and Groves (1969) for meridional winds.

It is shown that while CIRA-72 is still a useful model for many purposes, significant differences exist between it and the new radar data. The latter demonstrate important seasonal, latitudinal, longitudinal and hemispheric variations. The new meridional cross-sections are of great value. The common features with Groves (1969) are the equatorward cells in summer near 85 km; however their strength (~10 ms^{-1}) and size are less. Systematic and somewhat different variations emerge at higher (≥52°N) and lower (35-44°) latitudes.

INTRODUCTION

Since the development of the last CIRA in 1972, the number of radars providing winds in the upper middle atmosphere has increased significantly. Depending on the technique, these systems fill the data gap between ~60 km (the meteorological rocket network and other small rocket systems have provided winds to that height) and ~110 km (larger rockets, and incoherent-scatter radars provide some winds above this height). The radars include medium frequency (M.F.) radars or partial reflection systems giving data from 60/70-100/110 km; meteor radars, 80-110 km (and M.S.T. radars operating as meteor radars). Until now MST (VHF) radars have not given winds for a sufficient number of hours per day, or heights, to provide cross-sections of the type shown here: however a new extended data set from Poker Flat is discussed later. We show here data from 12 locations, which represent a good Northern Hemispheric (N.H.) North American chain (18-65°N, 90°W), an Oceanian chain (44°S - 35°N, 140°E) which is mainly in the southern hemisphere (S.H.), and some Western Europe data (44-68°N, ~0°E). (Of these, data are still being obtained at 7 locations, and also from two Antarctic stations not included here.) The methods of data analyses are discussed in detail elsewhere /1,2,3,4,5,6,7,8/. Generally however, tidal oscillations have been removed from days or groups of days, and the remaining mean winds and longer period oscillations plotted as height-time contours. Time resolution varies from 10-15 days to seasonal, and will be evident from each figure.

An attempt has been made to form composite cross-sections from the years 1978-1982 so that only the major temporal features remain. Detailed study of groups of years from Adelaide /9/, France /10/, Saskatoon /11/ suggest that, at least at middle latitudes, the main features of the circulation are repeated each year with relatively small interannual variability. Here we focus on those major features, and compare these with zonal winds from CIRA-72, and meridional winds from Groves' data compilation /12/. Tabulations of monthly mean values for most stations appear in Appendix . A more detailed presentation of these data, including individual years, will be made elsewhere /13/. The sign covention is as follows: for the zonal winds, positive winds are from the west (west or westerly winds) and negative winds are east or easterly winds. For the meridional winds, positive winds are from the south (south or southerly winds), and negative winds are north or northerly winds. It is also convenient to describe these latter as poleward or equatorward winds. The figures are rather consistent, but any differences are mentioned in the captions.

ZONAL WINDS

Generally, for latitudes as low as ~35°, there are westerly/easterly flows during winter-/summer-centred months below 95/85 km, and the reverse above (Figures 1-6, 8-12) as shown in CIRA-72 (Figures 7, 13). High latitude data, such as Kiruna and Poker Flat (Figures 1,2), which were not available for CIRA-72, can be seen to be reasonable extrapolations of mid-latitude data (e.g. Saskatoon 52°N, Figure 3). The data from Poker Flat are derived from meteor echoes. A recent analysis of the winds from turbulence echoes /14/ for 1980/1 show excellent agreement; suggesting that MST radars can provide monthly mean winds, depending on their power, location and the season. For lower latitudes (≤35°) the behaviour may be similar, but in general is more complex. At mid-latitudes (~45°) the reversals in the mesopause region are less clear in winter months, and are at a greater altitude (e.g. Figures 3,4,5,6). There is also more systematic mesospheric variability during the ~seven winter-like months; this is most evident in the high resolution (7-/10-d means) large altitude-range data from Christchurch and Saskatoon (Figures 6, 3). The causes of this are planetary waves, stratospheric warmings, and annual and semi-annual oscillations /15/. This is a major difference from CIRA-72, which due to lack of data in the lower mesosphere and averaging over years, has produced an unrealistically smooth winter vortex with a maximum in December/January. Indeed at latitudes near 50°, the CIRA winds for February and March are quite atypical (cf Figure 3). The differences between winter and summer circulations, especially the variability, heights of reversal and strength of lower thermospheric circulations have important implications for theories and models which now depend upon gravity wave momentum deposition to close the westerly and easterly flows /16,17/. It is likely that the characteristics of the gravity wave fluxes, e.g. sources and group velocities, and perhaps planetary waves, also have strong seasonal variations which are reflected in these contours.

Winds from most of the mid-latitude stations (Figures 3,5,6; Saskatoon, Monpazier, Garchy, Christchurch) also illustrate the regularity of the equinoctial transitions and their rapidity. This is especially evident in the Saskatoon winds, where the composite of 4 years of continuous data differs little from individual years. Because of this September is more winter-like and May more summer-like (Northern Hemisphere), than CIRA-72 indicates.

We now compare the winds data in more detail. For example: the summer reversal heights, which in CIRA-72 decrease toward lower latitudes, from ~90 km at 50° and ~80 km at 35°, to 70-80 km at 20° (Figure 13). Our data show more global variability. Kiruna and Poker Flat have similar contours below the reversal (~88 km), but the upper westerly (eastward, E) flow at Kiruna, which is based on ~15d of data, is much stronger. Near 45°, Saskatoon, Monpazier, Christchurch and CIRA-72 (Figures 3,5,6,7) are fairly consistent, although the descending spring easterly tongue is so strong and early over France, that the negative cell is split into two -- a feature not unlike that at 20° in CIRA-72. This downward progression of the zero line could be a critical layer effect associated with gravity waves and/or planetary waves. However the Durham (43°) contour is quite different in these summer months, with westerly flow 80-110 km, and very low vertical gradients (0.75 ms^{-1} km^{-1} vs 3.75 ms^{-1} km^{-1} at Saskatoon). This low reversal height makes it quite similar to CIRA-72 at 35°. Hence large longitudinal differences, and rapid latitudinal differences, are evidenced between Durham and Monpazier, and Durham and Saskatoon respectively. It should be noted that the Durham meteor winds analysis assumes a linear variation of the mean wind with height, which may account for the smooth variation of the contours with height. Near 35°N, Atlanta and Kyoto are similarly dominated by westerly flow above ~80 km (Figures 8,9); and they both show some negative easterly flow in fall and early winter. The absence of the narrow spring tongue is possibly due to an absence of March and April data at Kyoto, and interannual variability at Atlanta. Other Kyoto data from 1979/80 /8/ do show negative easterly flows up to 88/90 km in March and April. It has also been noted at Atlanta /18/, that the circulation there may be tropical (Figure 13) or mid-latitude in pattern: actually to form the composite contour of Figure 8, a year which was somewhat more representative of a mid-latitude circulation was eliminated. In summary, Atlanta and Kyoto demonstrate longitudinal differences; and also some features like CIRA-72 at 20°, e.g. easterly flow near November and strong westerly flow in late summer. Meanwhile Adelaide at 35°S (Figure 10) is more like CIRA-72 at 35° or even 45° (Figure 7), with summer easterly flow up to 85 km. It is clear from studying CIRA-72, that early Adelaide data strongly influenced the contours at that latitude; and that Adelaide is more like a northern hemisphere mid-latitude (~45°) station. Winds from the previous 10 years of meteor and MF radar observations also showed the spring easterly tongue, but the easterly vortex was below 80 km. For 20°, CIRA-72 (Figure 13) differs from the mid-latitude pattern of Figure 7; as the descending tongue of easterly flow now dominates the N.H. mesopause region from November-April, and there is strong westerly flow above 90 km in late summer and early fall. Puerto Rico and Townsville (Figures 11,12) are quite similar to each other, in that they both have prominent easterly spring tongues, and the easterly rises in height again to ~90 km late in the summer: these features are similar to CIRA-72 at 20°. However the winter circulation November-January (May-July in the S.H.) from 80-100 km, is still dominated by westerly flow. Thus both locations still have strong remnants of the mid-latitude circulation, and are not unlike CIRA-72 at 35° (or Adelaide) in these respects.

The comparison between CIRA-72 and the radar winds is well illustrated in height-latitude cross-sections; and we show here December (an early soltice month, clear of N.H. stratospheric warmings) and July for ~90°W in the N.H., and ~140°E in the S.H. From CIRA, July (June 15 - July 15) and January (December 15 - January 15) are shown (Figures 14, 15). The time rates of change are small in mid-season, so that conclusions drawn here are usually typical of the entire soltitial seasons. Only the zero contours, and maxima of cells are shown for CIRA-72. The lack of hemispheric symmetry is immediately obvious: the winters are most alike and even then the N.H. zero line is 10-15 km higher, reflecting smaller poleward temperature gradients there. Comparing with CIRA-72, two other points emerge: the upper zero lines were not available for that model; and there is an easterly tropical cell above 87 km which is not evident at our four low latitude stations. For the summers, these stations again do not have the easterly flow above 87 km, which is shown in CIRA. The main differences between the S.H. and N.H. at these longitudes, are due to the consistent westerly flow at and above 80 km revealed at Durham (43°N) and Atlanta (35°N) and the high reversal heights in Oceania. Thus in both hemispheres, the systematic reduction in the height of the zero line with decreasing latitude which is shown by CIRA-72, is not in evidence.

Some of the differences evident in Figures 14 and 15 will be due to planetary waves (n=1,2), especially in the N.H. These could also explain the differences between Durham and Monpazier. Satellite data will be useful in quantifying this effect. However significant differences between hemispheres have emerged, stressing the need for global reference atmospheres.

MERIDIONAL WINDS

The tabulations of Groves show strong summer-centred equatorward flow (Fig. 7,13), which dominates the year: the centre of the core moves from 85 to 100 km from 50 to 20°. This summer flow has recently been studied at mid-latitudes of the N.H. near 90 km /19/ using data from radio and radar techniques. Although our data generally show this feature, the flow is weaker; and the seasonal and latitudinal variability is larger. As well as the summer flow (which is consistent with cooling at high latitudes, and hence the zonal winds through the thermal wind equation) Poker Flat (65°N), Saskatoon (52°N) and Christchurch (44°S) (Figures 2,3,6) also have poleward flow in the winter mesosphere, and equatorward above /20/. These may be portions of two cells, below and above the mesopause respectively; the return flow could be in the stratosphere for the former /11/, and the poleward flow would have to be above ~110 km for the latter. Notice the different contour shapes at 52°N and 44°S illustrating hemispheric differences. Durham also shows the summer equatorward flow (Figure 4) but overall its contour shapes differ significantly from Groves (Figure 7,13) and neighbouring North American contours. For the low latitudes: at Atlanta (Figure 8) the phase of the changes is retarded by ~2 mths; Kyoto (Figure 9) has more features in common with Durham and Saskatoon; and in the Southern Hemisphere, Adelaide and Townsville (Fig. 10,11) are quite similar to Christchurch. Our data differ considerably from Groves' compilation, and multiple meridional cells may be required to organize the data: longitudinal variations are evident.

Finally we show meridional height-latitude cross-sections as for the zonal wind, but compare here with Groves' data (Figures 16, 17). For July, the general agreement is quite good, apart for the fact already noted, i.e. the N.H. summer equatorward flow is weaker and more restricted in height than Groves. December's patterns (Figure 17) illustrate the lack of hemispheric symmetry, as the S.H. summer flow is more like Groves. The contours of the N.H. winter flow are quite different from Groves; although overall there is poleward flow within the mesosphere in both cross-sections.

CONCLUSION

The radar zonal wind cross-sections differ considerably from CIRA-72, especially regarding winter variability and heights of reversals. There is good evidence that winds from 43-52° in the northern hemisphere, vary quite significantly with latitude and longitude, being near CIRA's 45°-50° in some cases and CIRA's 35° in others; and that winds ~35°N may demonstrate mid-latitude (≤35° CIRA-72) or tropical characteristics (20° CIRA-72). In the southern hemisphere 35° is similar to CIRA-72 at 35° or even 45° and is more mid-latitude in behaviour. The winds from near 20° show a mixture of mid-latitude and tropical characteristics. The meridional cross-sections evidence considerable seasonal and latitudinal variability; the main feature being a summer equatorward (~10 ms^{-1}) mesospheric flow. However this does not dominate the year as in Groves' compilation. In other months at mid-latitudes there is considerable poleward flow in the mesosphere. It is possible that the elimination of tidal components, which is crucial for these weak winds, was not complete in the earlier data.

Overall, and based on other data from the various locations, the conclusions reached here about the zonal flows are probably valid. However given the weakness of the meridional flow, the shapes of the contours for some of these cross-sections are less certain -- given the probable importance of gravity wave momentum deposition for the zonal flow, this process will certainly also contribute to variability in the meridional flow. Nevertheless the main differences from the Groves' data are expected to remain.

REFERENCES

1. A.H. Manson, C.E. Meek and J.B. Gregory, J. Geophys. Res. 86, 9615 (1981).

2. M. Massebeuf, R. Bernard, J.L. Fellous and M. Glass, J. Atmos. Terr. Phys. 41, 647 (1979).

3. R.A. Vincent and T.J. Stubbs, Planet. Space Sci. 25, 441 (1979).

4. M. Salby and R.G. Roper, J. Atmos. Sci. 37, 237 (1980).

5. M.J. Smith, Ph.D. Thesis, University of Canterbury, Christchurch, N.Z. (1981).

6. D.A. Carter and B.B. Balsley, J. Atmos. Sci. 39, 2905 (1982).

7. R.R. Clark, J. Atmos. Terr. Phys., 45, 621 (1983).

8. T. Aso and R.A. Vincent, J. Atmos. Terr. Phys. 44, 267 (1982).

9. W.G. Elford, Nature, Lond. 261, 123 (1976).

10. M. Massebeuf, J.L. Fellous, A.H. Manson and C.E. Meek, J. Atmos. Terr. Phys. in press (1984).

11. C.E. Meek and A.H. Manson, Advances in Space Research, this issue.

12. G.V. Groves, J. Brit. Interplanet. Soc. 22, 285 (1969).

13. A.H. Manson et al., Report No. 3, Dynamics Group, Institute of Space and Atmospheric Studies, University of Saskatchewan, Saskatoon, Canada (1984).

14. B.B. Balsley and A.C. Riddle, J. Atmos. Sci., in press (1984).

15. A.H. Manson, C.E. Meek and J.B. Gregory, J. Geomag. & Geoelectr. 33, 613 (1981).

16. R.S. Lindzen, J. Geophys. Res. 86, 9707 (1981).

17. J.R. Holton, J. Atmos. Sci. 39, 791 (1982).

18. P.M. Dolas and R.G. Roper, J. Atmos. Sci. 38, 182 (1981).

19. G.D. Nastrom, B.B. Balsley and D.A. Carter, Geophys. Res. Lett. 9, 139, (1982).

20. G.V. Groves, Phil. Trans. Royal Soc. Lond. A296, 19 (1980).

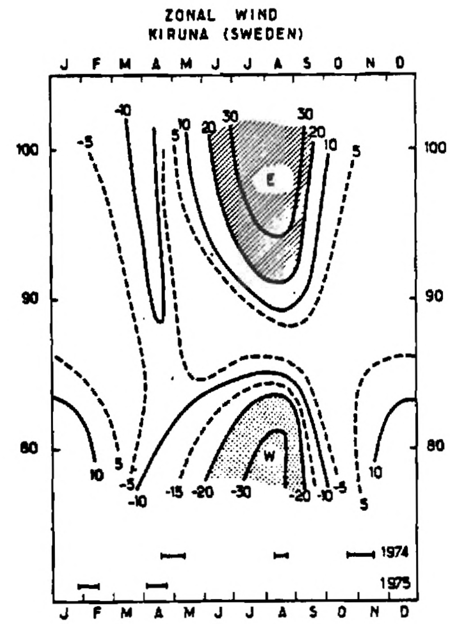

Figure 1 Kiruna, 68°N, 20°E (Massebeuf and Fellous). The positive westerly flow is marked E for eastward; and negative easterly is W for westward.

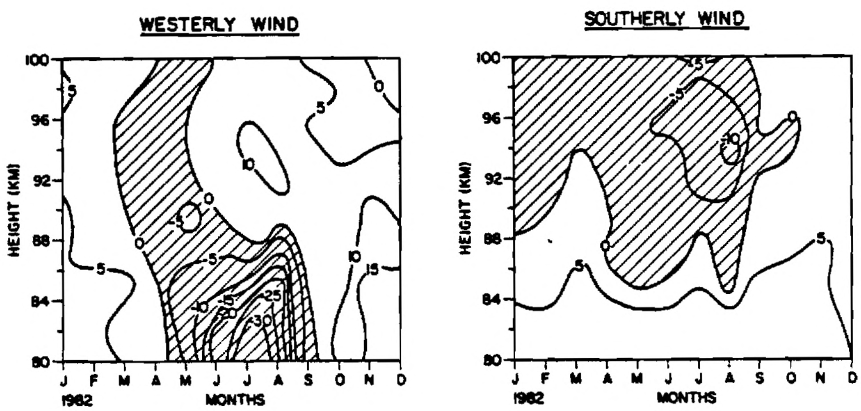

Figure 2 Poker Flat, 65°N, 147°W.

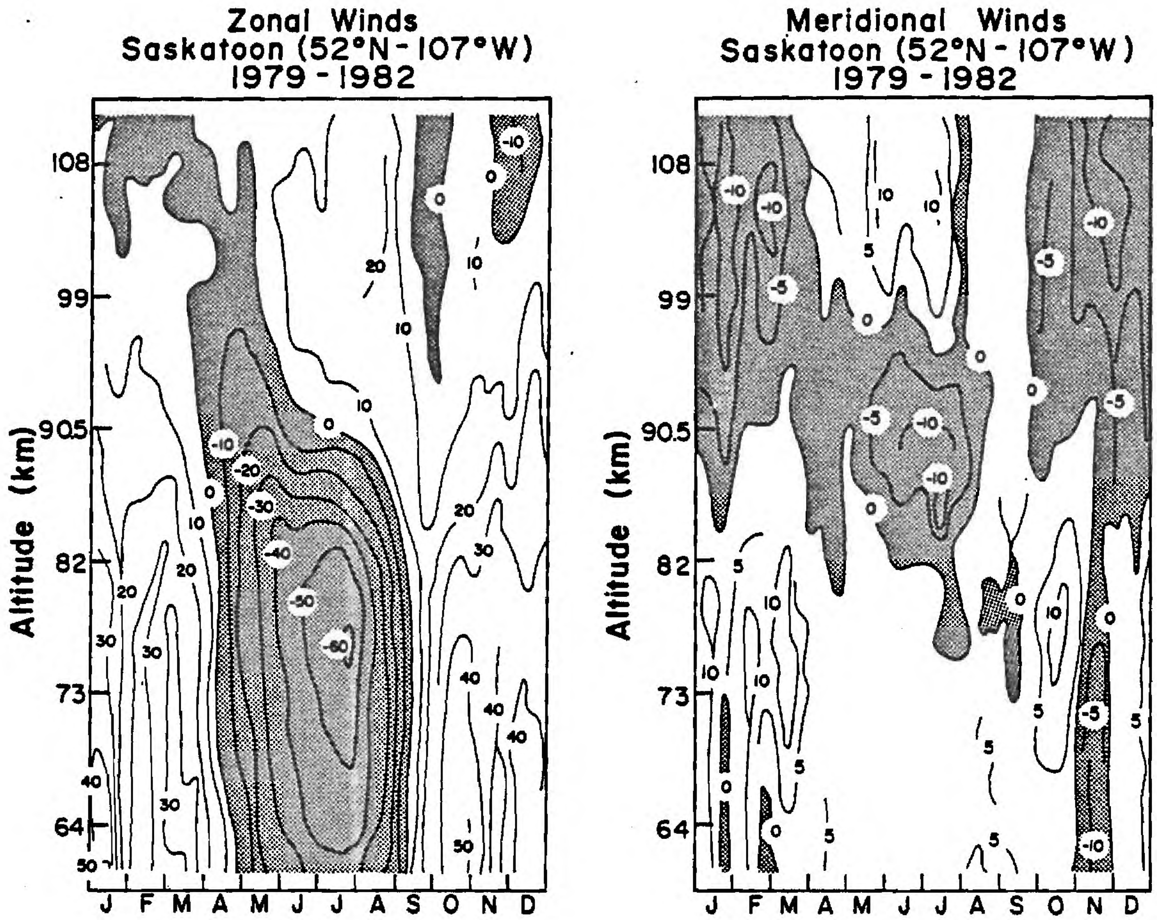

Figure 3 Saskatoon, 52°N, 107°W: 10d means used; s.d. typically 4 ms^{-1} for EW, 6 ms^{-1} for NS at 90 km.

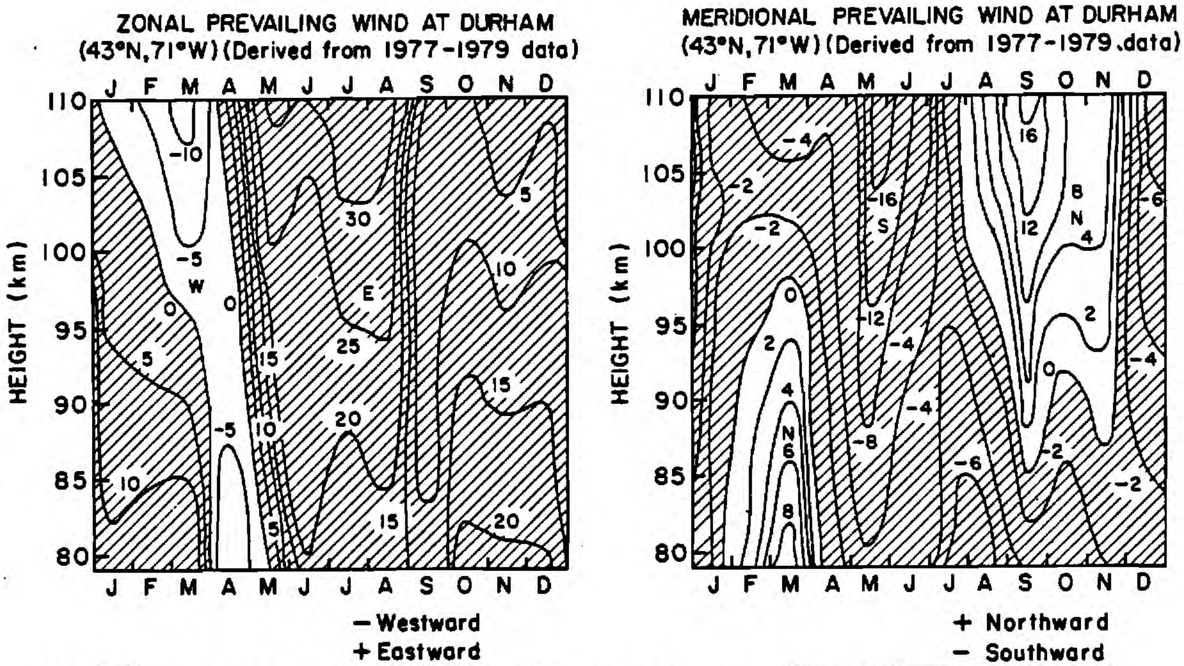

Figure 4 Durham, 43°N, 71°W: the westerly (E, eastward) flow is cross-hatched only in this case. Positive southerly flow is marked N for northward.

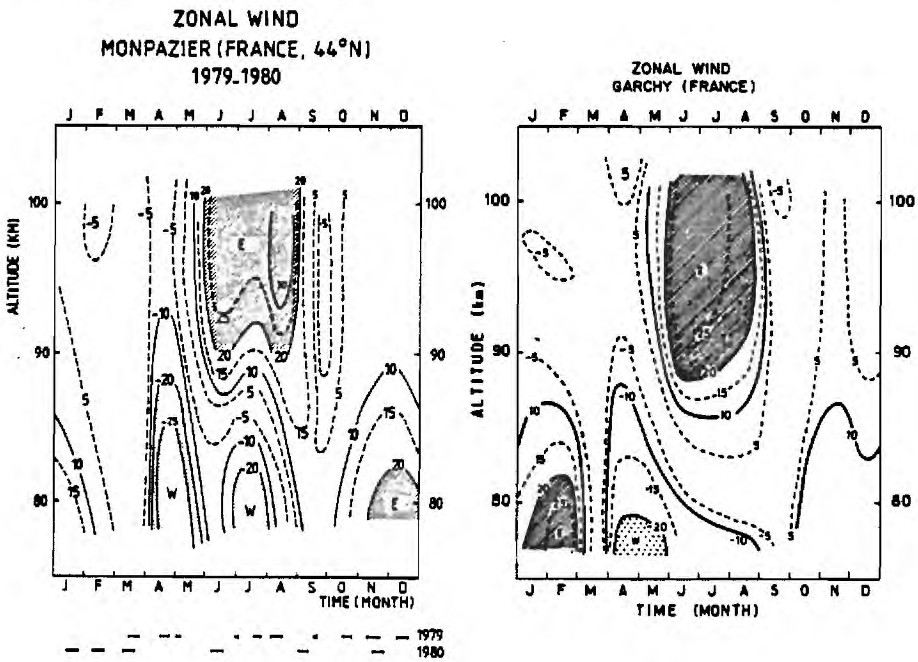

Figure 5 Monpazier, 44°N, 1°E; Garchy, 47°, 3°E, 1970-76 (Massebeuf, Fellous): westerly flow is marked E for eastward, easterly is W for westward.

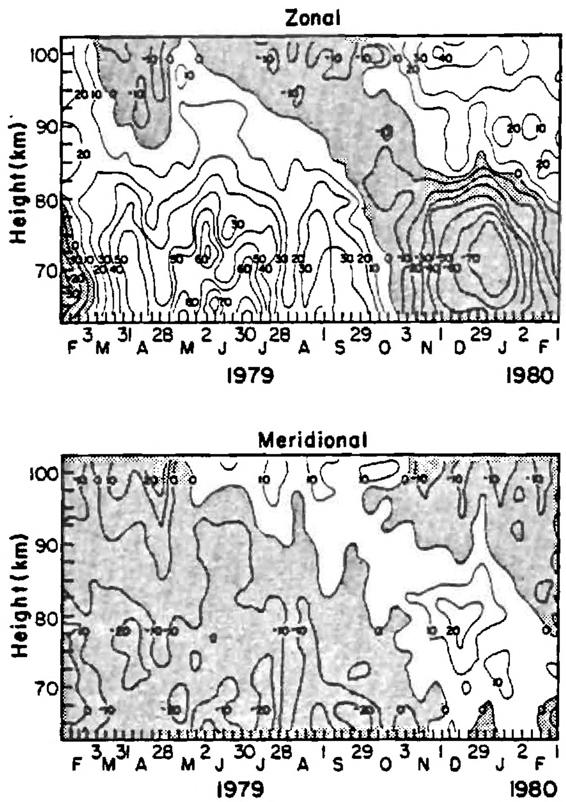

Figure 6 Christchurch, $44^{o}S$, $173^{o}E$: 7d means used. Positive meridional flow is northward, and hence equatorward.

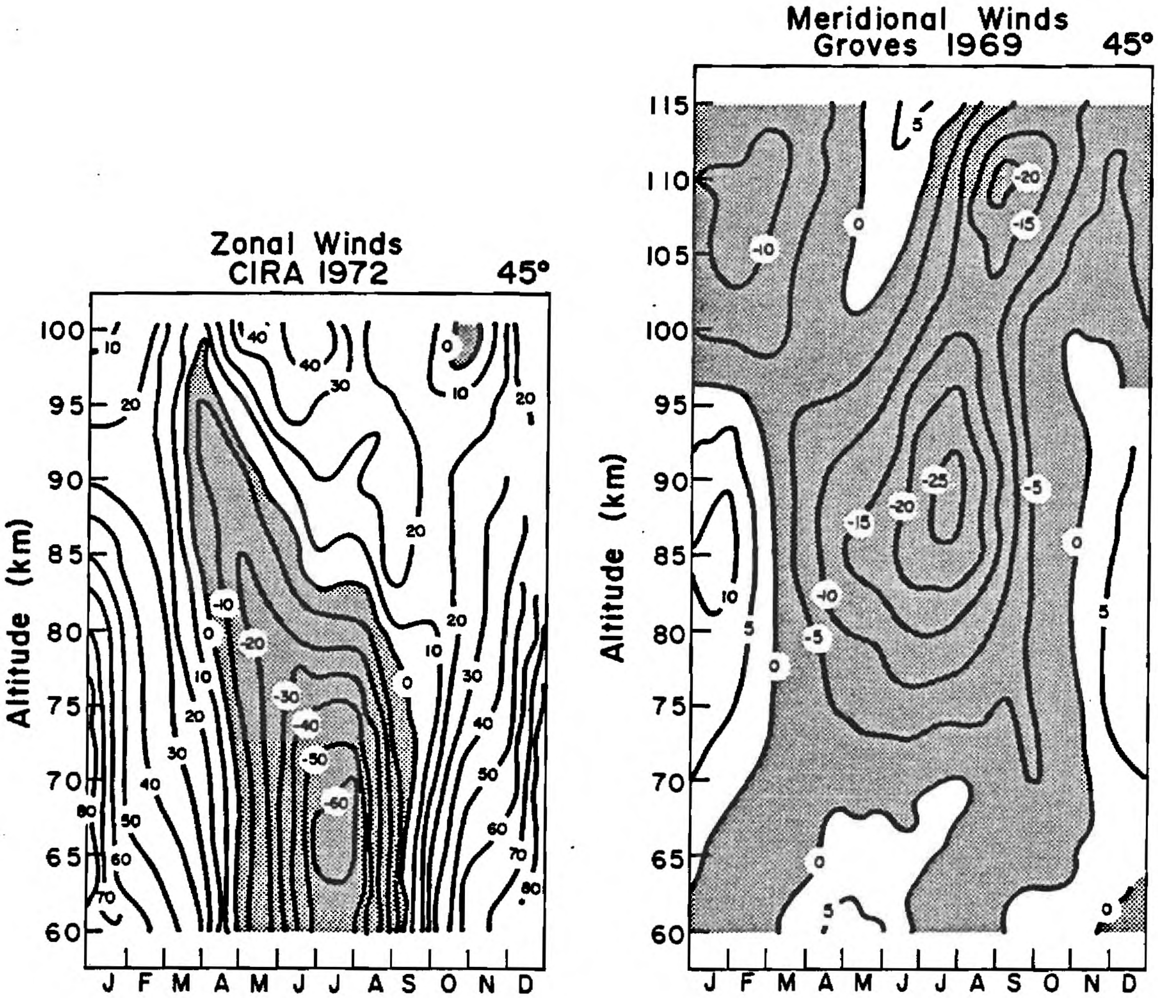

Figure 7 CIRA-72, Groves 1969: 45°.

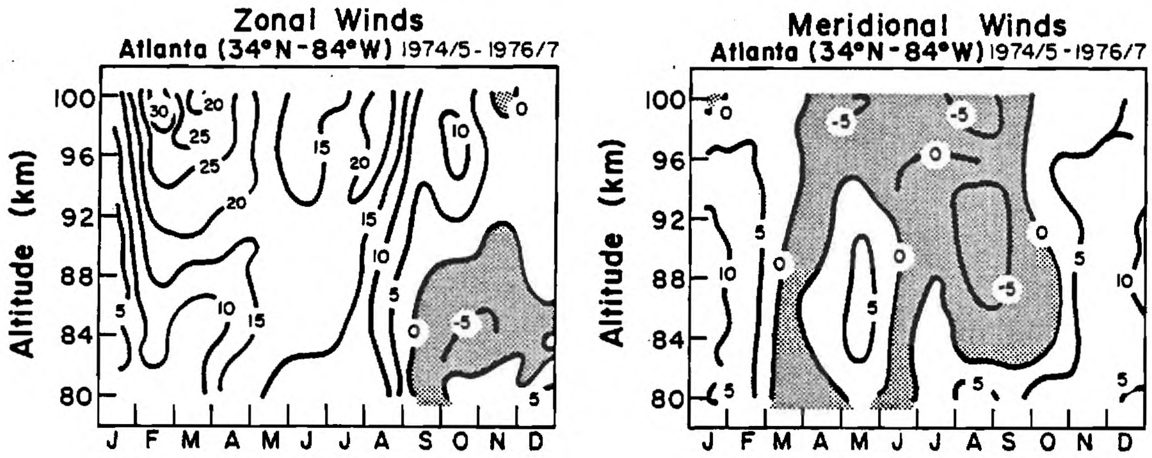

Figure 8 Atlanta, 34°N, 84°W.

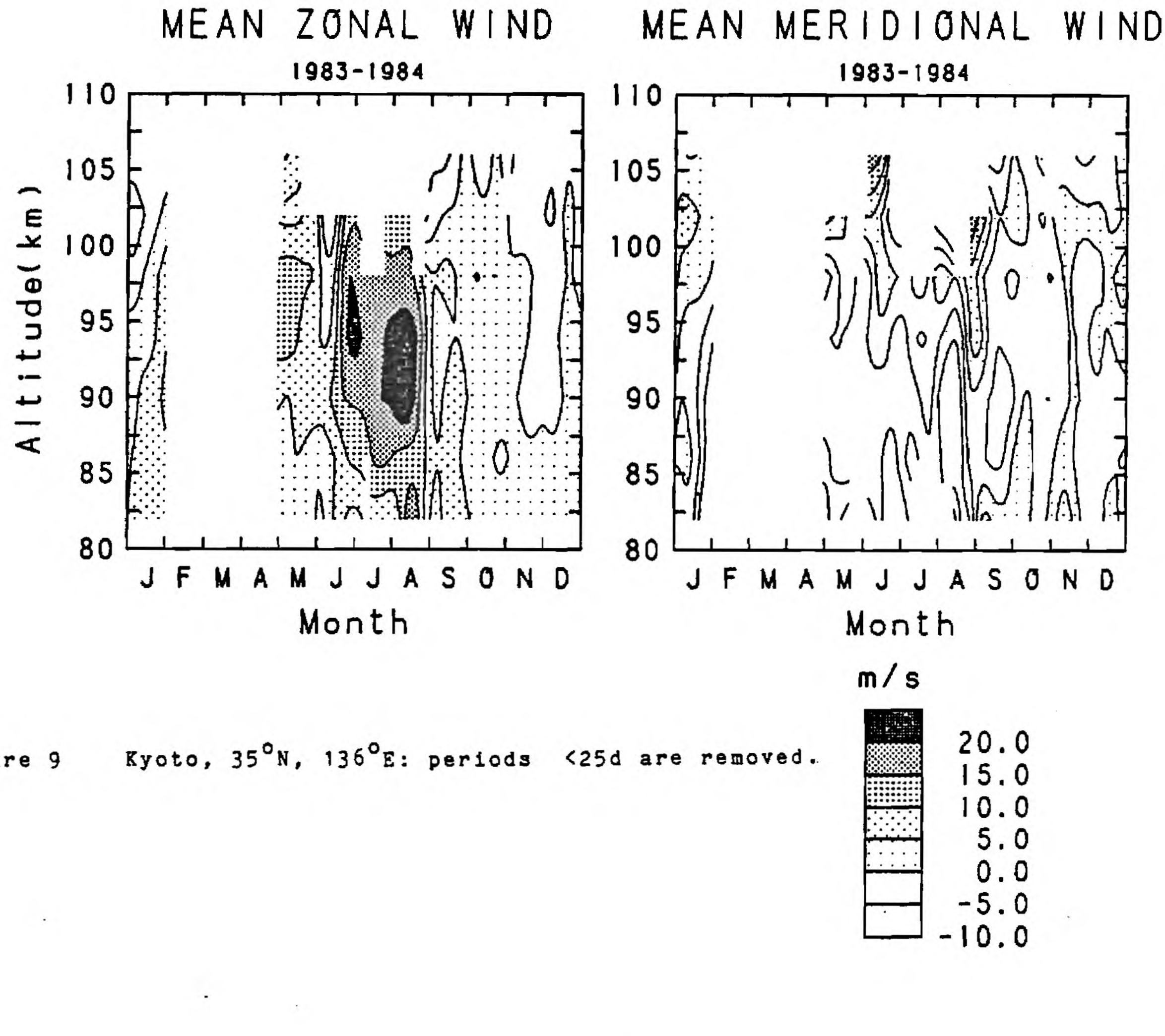

Figure 9 Kyoto, 35°N, 136°E: periods <25d are removed.

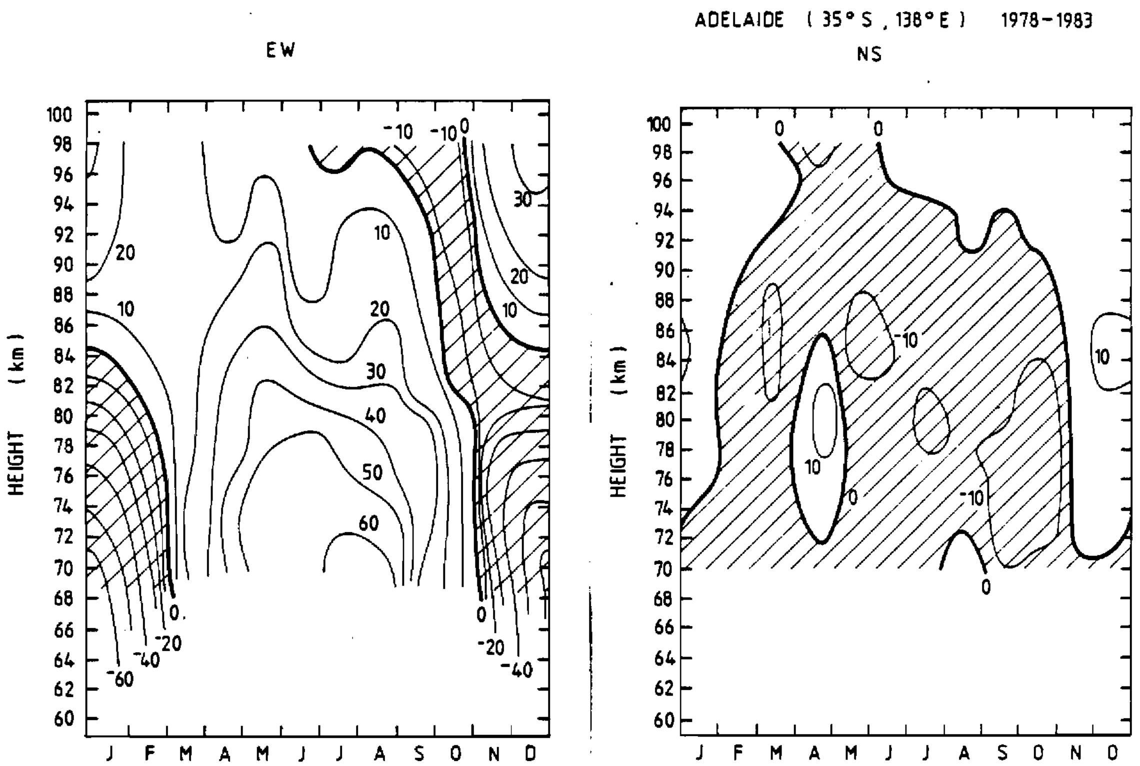

Figure 10 Adelaide, 35°S, 138°E: s.d. typically 7 ms^{-1} for EW, NS at 90 km.

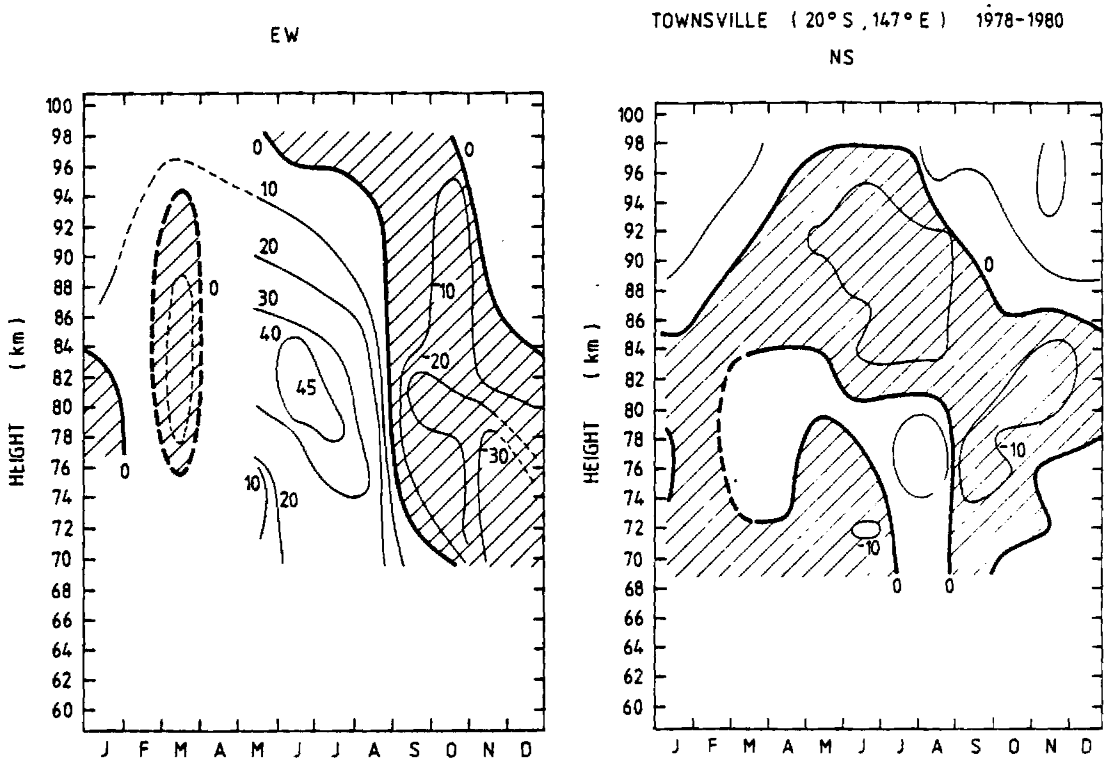

Figure 11 Townsville; 20°S, 147°E (Elford, Vincent, Craig).

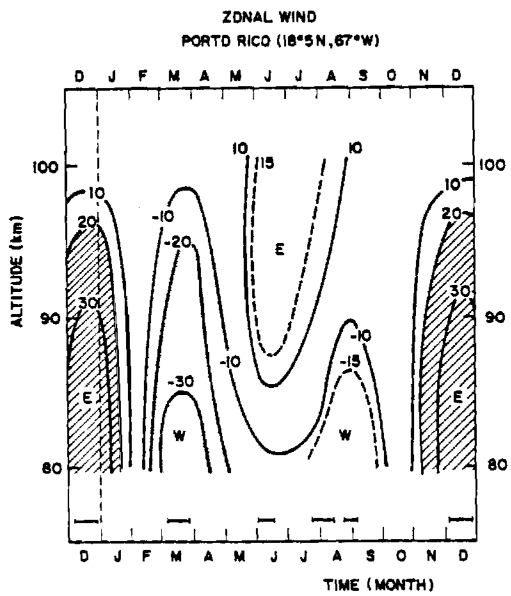

Figure 12 Puerto Rico, 18°N, 67°W (Massebeuf, Fellous): positive westerly flow is marked E for eastward.

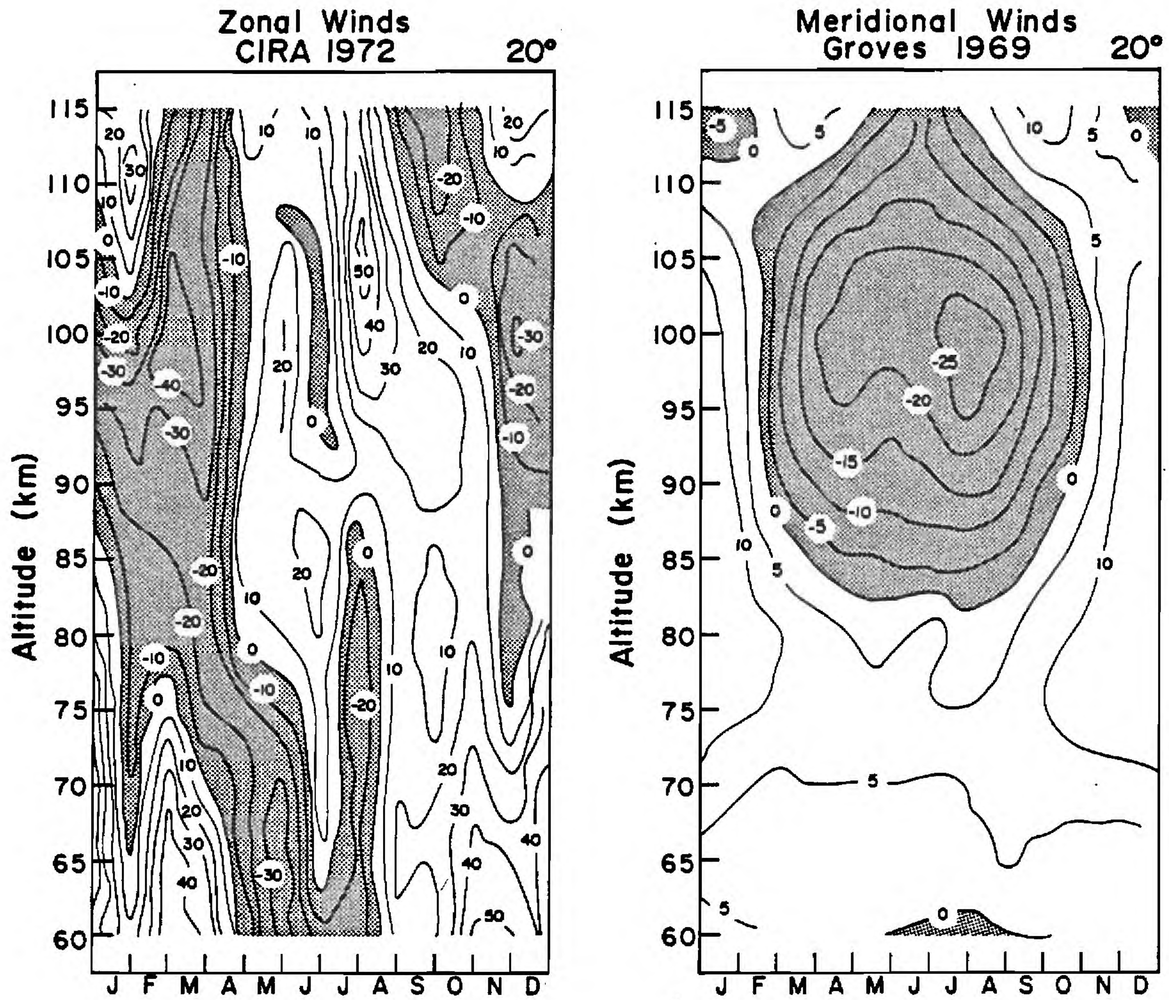

Figure 13 CIRA-72, Groves 1969: 20°.

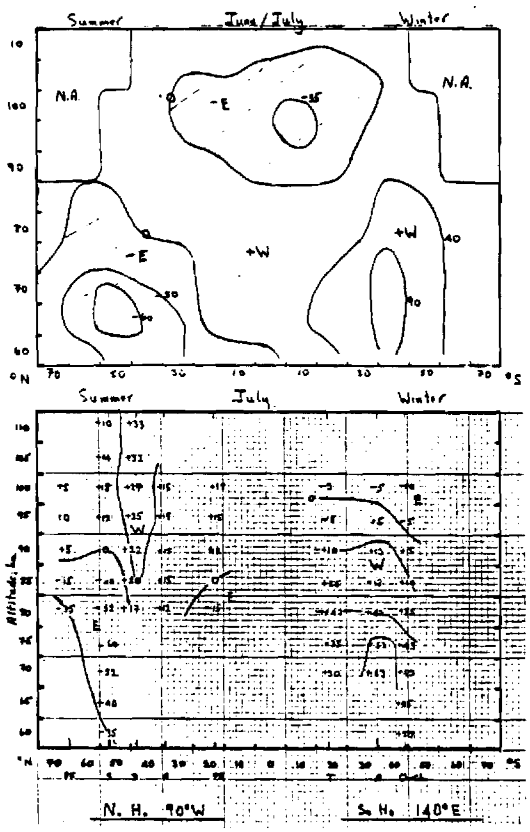

Figure 14 Zonal winds, July.

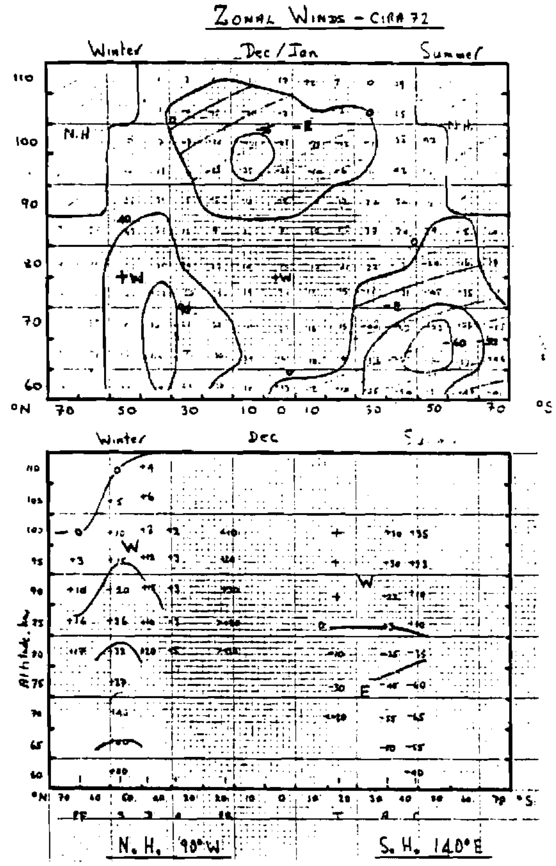

Figure 15 Zonal winds, December/January.

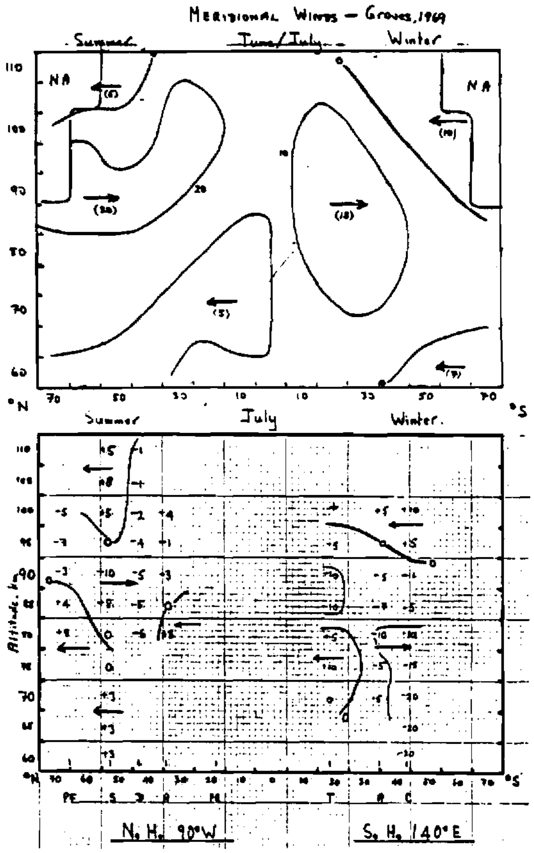

Figure 16 Meridional winds, July.

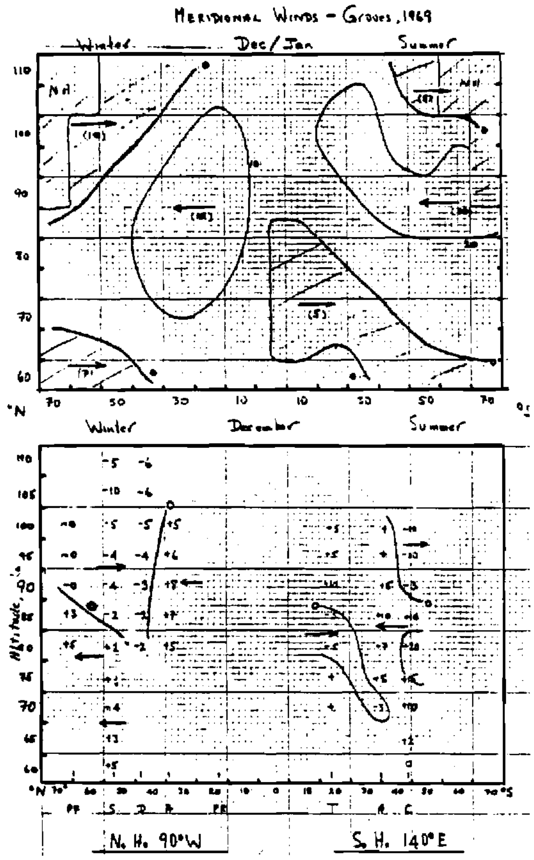

Figure 17 Meridional winds, December/January.